FOR OFFICIAL USE ONLY

AVIATION MEDICINE PRACTICE

TITLE II—MILITARY-MEDICAL OPERATIONS COURSES

PREPARED BY

BUREAU OF MEDICINE AND SURGERY

BUREAU OF NAVAL PERSONNEL

NAVPERS 10839

MARCH 1949

FOR OFFICIAL USE ONLY

AVIATION MEDICINE PRACTICE

TITLE II—MILITARY-MEDICAL OPERATIONS COURSES

PREPARED BY

U.S. BUREAU OF MEDICINE AND SURGERY

BUREAU OF NAVAL PERSONNEL

NAVPERS 10839

MARCH 1949

PREFACE

This text is designed to acquaint medical officers who have had no previous training in aviation medicine with the problems that arise in that field.

These problems are numerous and complex, and a detailed discussion of all of them has not been attempted. For the most part they are concerned with the physiology and psychology of flight, and with dynamics, pharmacology, and pathology.

The human being, in his natural evolution, became adapted to the environmental conditions found upon the surface of the earth. However, now he has been called upon to work in a different environment, without benefit of evolution. Aviation medicine works hand in hand with aviation engineering to compensate for his many deficiencies in this new environment. A better understanding of human physiology at high altitudes and high speeds has led to the development of mechanical devices, etc., which make pilots efficient and comfortable while flying in this new air age.

This book has been prepared by the Aviation Medicine Division of the Bureau of Medicine and Surgery and the School of Aviation Medicine and Research, Naval Air Station, Pensacola, Florida, with the cooperation of the Naval Reserve Training Publications Project of the Bureau of Naval Personnel.

NOTE.—Explanation of superior figures used throughout this book will be found in the bibliography at the end of each chapter.

CONTENTS

CHAPTER 1

THE BEGINNINGS OF AVIATION MEDICINE *

When the Wrights launched their contraption of sticks, wire, and fabric for a 12-second flight on a gray December day in 1903, they started something—something nearly as far-reaching in its ultimate effect on the social order as the sputtering little engine with which James Watt ushered in the Industrial Revolution of the Eighteenth Century. The public took but casual interest in what was going on at Kitty Hawk. There is nothing to indicate that anyone in the medical profession took any more interest in it than the rest. Yet there was to be "an indissoluble linking of medical science and the art of flying,"[1] as we shall see.

While people in this country were still thinking of the flying machine as a sporting proposition, useful only in giving the daredevil a new way of breaking his neck, the Europeans began to see possibilities in it, military possibilities. No one envisioned aircraft capable of carrying sufficient payloads to be commercially worthwhile; but the thing might serve a purpose in obtaining that crucial component of any military operation—information. Spies, scouts, patrols—these were slow, laborious, uncertain ways of getting information about what the enemy was up to. If this new machine could give a man a chance for a quick look from above, and get him back, that would be distinctly worthwhile. Then there was the matter of artillery fire. Some long range guns were being developed, and it was difficult to make sure the shells were falling in the right place. Here again, a quick look at the right moment would be worth a lot.

The Germans appear to have been the first to take these matters seriously enough to do much about it. And they were also the first to recognize that flying—unnatural human endeavor that it is—would require some help from the medical department. Armstrong reports that as early as 1910 the Germans had formulated minimum physical standards for aviators, and by 1915 had a medical service for aviators[2]. Meanwhile, World War I had come along. The Allies still had much to learn about the use of aircraft and about aviation medicine. Much of it they learned the hard way.

There was a great spirit of camaraderie among those early airmen. It is said that enemy aviators gave each other the grand hailing sign when they happened to pass close aboard, as they went about their business of scouting each others' lines. Presumably the ground troops objected to this scouting with such gunfire as they could bring to bear, but that was all perfectly legitimate—a chance one had to take—and had nothing to do with the good fellowship among flying men.

No one seems to know who started it—probably each side blamed the other—but it is said that one day somebody carried aloft a pistol and took a pot shot at a friendly enemy in the air.† He didn't know it, but he changed things almost as much as had the Wrights. He demonstrated that the airplane could be used as a striking weapon.

There followed the whole trend of development aimed at giving the man operating this new weapon an advantage over his adversary. Speed, maneuverability, range, fire power, rate of climb, ceiling; all these things became matters of rapid competitive development. With these developments came a host of problems that had to be solved by the medical officer; problems of accelerative forces, anoxia, fatigue,

* Prepared by Captain Wilbur E. Kellum, MC, USN

† The writer has not been able to document this. It came to him from some of those pioneer aviators who were there. Perhaps the first offensive act was dropping a bomb or two. The significance is the same but it's not quite such a good story.

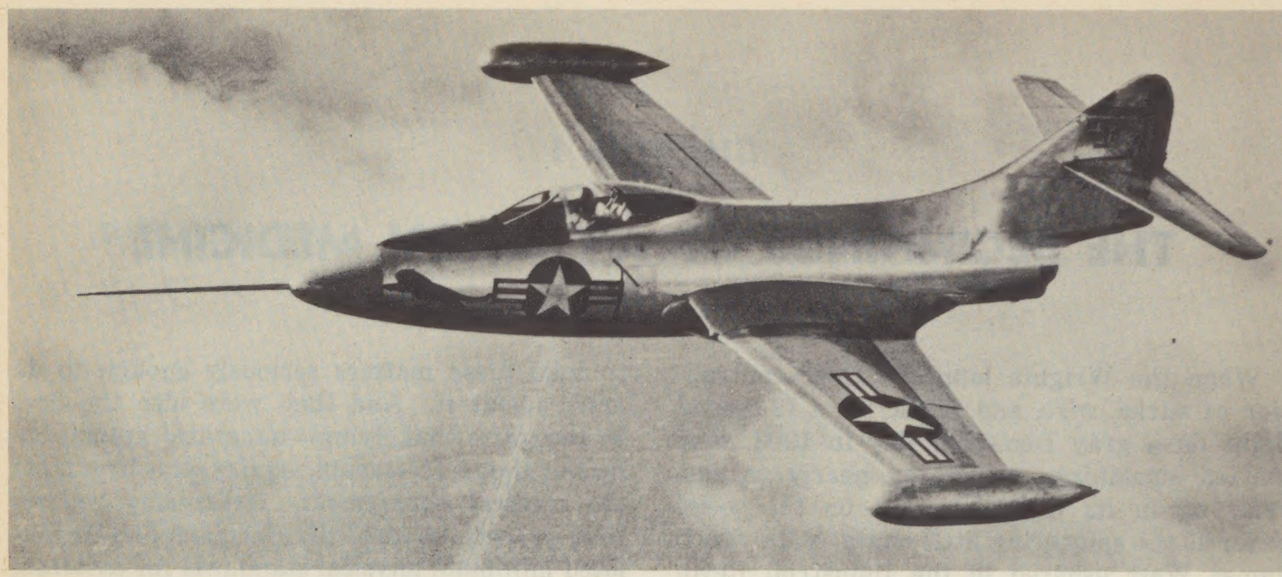


Figure 1-1.—F9F Panther.

psychological stress, and others. These problems developed swiftly—there was no time for leisurely investigation. It will be instructive to examine the British experience.

James L. Birley, a pioneer in aviation medicine, had this to say in 1920: "Up to this time (two years after the beginning of the war) officers were still being accepted as pilots and observers on the flimsiest medical examination or even on none at all, while those who were systematically examined were adjudged on standards which were originally laid down from the point of view of the ability of the candidate to march and to shoot from his right shoulder. It happened, accordingly, that a prospective candidate might be accepted with a blind left eye, or rejected because of flat feet. This anomaly was corrected by the institution of a central board for the examination of all candidates for the flying services."[3]

Dr. Birley went on to indicate that a field organization was necessary. Suitable medical officers were obtained for duty with the squadrons with a view to learning about the duties expected of fliers and the conditions under which they were performed, to acquiring detailed personal knowledge of the fliers, and to gaining their confidence. A number of beds were reserved in a convenient hospital for the study of flying personnel whose disability appeared to be directly related to their peculiar work. In the last 16 months of the war nearly 2,000 flying officers passed through this unit. Of these, 40 percent were deemed to be suffering from "the fatigue inseparable from active service (flying in the combat zone)."* The intelligent interest of commanding officers was stimulated by encouraging them to visit this unit. Birley states that many of them became extraordinarily astute psychological observers.

Lieutenant Colonel E. G. Seibert, one of the American pioneers in the field of aviation medicine, stated in 1919:

"The experience gained by the British and French service was accomplished at the expense of many wrecked lives and smashed aeroplanes. The onrush of the German hordes in 1914 gave no time for investigation. Every man of England, France, and Belgium was called upon to give his last ounce of energy to the service. At the end of the first year of the war the result of the stress was shown in the appalling individual inefficiency developed by the Royal Flying Corps. Sixty-five percent of the total strength of the corps was unfit for duty. Because of demands of other services, replacements were difficult to make.

A remedy was sought, and attention was at-

* The term "operational fatigue" had not been discovered, that convenient category was to be a development of World War II.

tracted to medical efforts to conserve the efficiency of flying men. Concentrated effort was made during the following year to bring about changes in the care of these men and apply certain principles believed to be needful because of changed conditions. The end of this year showed the inefficiency of the corps reduced from 65 to 20 percent, and in the third year of the war, a further reduction to 12 percent."[4]

It would be incorrect to imply that this improvement was due entirely to better care of the flier. We know that methods of selecting candidates for training were being improved and, certainly, commanding officers were learning how better to conserve the usefulness of their flying officers. It is fair to say that the medical men who were pioneering the field of aviation medicine had much to do with all of this.

When the United States entered the war there was a considerable body of experience to guide the development of medical services in the Army and Navy. During the winter of 1917-1918 Major T. C. Lyster and Major Isaac H. Jones visited the allied forces in England, France, and Italy.[5] Their experiences and observations are reported at length in the volume titled *Air Service Medical* published by the Government Printing Office early in 1916.[6] In a recent personal communication to the writer Dr. Jones states, "They were making pilots out of tired soldiers. Also, they used them until they didn't come back. Hence we created the flight surgeon, for the need was obvious (more obvious, naturally, to us visitors than to those right in the midst of it)."

Meanwhile a "medical research board" had been appointed to study all conditions which affected the efficiency of military pilots, and to consider all matters pertaining to their physical and mental fitness. The board immediately, January, 1918, established the Air Service Medical Research Laboratory. In May 1919, a section of this laboratory was established as the "School for Flight Surgeons". Through a series of changes, during which the Air Service Medical Research Laboratory was abandoned (1920), this school has survived as the present Air Force School of Aviation Medicine at Randolph Air Base, San Antonio, Texas.

The discussion thus far has indicated how the idea of a special medical service for military aviation evolved from an imperative need.

Figure 1-2.—F2H.

The creation of the flight surgeon has been reported, and it has been indicated that his work was early concerned with both the selection of candidates for flight training and the care of the flier. Inherent in the situation which brought forth the new specialty of aviation medicine is a new philosophy of the function of the military officer.

Up to this period the medical officer had been primarily concerned with the treatment of the sick and wounded and with the protection of the physical health of the military unit. "The experienced soldier, not without reason, considered his credentials for knowing 'what his men could stand' at least as good as those of his medical colleague. He argued to himself that a doctor was in his element when he had someone ill to attend to, and consequently out of it when dealing with fit men. This criticism had a great deal of truth behind it. We were, to put it frankly, ill equipped to answer the conundrums with which we were confronted."[3] From this point onward the problem of the specialist in aviation medicine was to learn as much as possible about the work of the aviator, to study the psychological, physical, and physiological stresses involved in military flying, to find ways of selecting for training those who could best endure these stresses, and means of conserving the efficiency of those who had been trained. To understand these matters and, equally important, to command the confidence of the flier, it was early recognized that the medical officer must participate as fully as possible in all types of flying. Out of this participation has developed a close mutual understanding and community of effort which is unique in the history of relationships between the medical and the military professions.

The flight surgeon became a member of the team. He did not confine his interests to the clinical care of those who came to the dispensary for it. To be sure, he was there for sick call but his interests and activities ranged far beyond that. He was interested in flying. He actively participated in the operations of his outfit. He worked, flew, played, lived with his fliers. He knew each of them better than did the commanding officer, knew the commanding officer better than did any of them. Usually he had the respect and confidence of all.

He knew the conditions under which the pilots flew. He concerned himself with their problems, which ranged from small personal or family situations to ways of improving oxygen equipment, what to do about blackout (the Navy was pioneering dive bombing then), and eventually to such larger problems as cockpit design and instrumentation. At the same time he knew the problems and troubles of the commanding officer, the operational plans and schedules, the personnel problems. His field of interest was broad. It encompassed something of several medical specialties, reached across certain of the basic sciences. Ophthalmology, cardiology, otolaryngology, psychiatry, general medicine; these were instruments of daily use. Physiology, psychology, physics, aerology—these, among others, were areas in which he was at home. The flight surgeon's job had many facets, endless opportunity.

The story of aviation medicine during the ten years after World War I can be told briefly. Public interest in armaments, in all things military, dropped off sharply. The war to end all wars had been won; no one knew the peace was to be lost. Aviation suffered as seriously as the rest. It had a future in commerce, but at first this was not recognized; that depended upon further improvements of design and performance, and money was not available for the necessary research. Progress in aviation was slow during this decade. Aviation medicine kept pace with it. The decade is marked by only a few highlights which should be remembered.

Figure 1-3.—EK-19.

By 1926 the gradual increase in civilian flying reached a point where the need of some control was necessary. Airplanes, even then, were no respecters of state boundaries. Control, to be effective, must be federal. The Bureau of Air Commerce was formed in the Department of Commerce. It was to pass through a series of changes to become the Civil Aeronautics Administration of the present, but included a medical section from the beginning. Dr. D. A. Myers, an Army flight surgeon, had begun his studies on the physiology of instrument flying, which was to constitute one of the outstanding contributions to the technical advancement of aviation. Then, in 1927, Charles A. Lindbergh made his historic flight, and suddenly the whole country was air-minded. In the same year Pan-American Airways started its far-flung development.

By 1929 there were enough physicians associated with aviation, civil and military, to establish the Aero Medical Association. A year later this organization started publishing the *Journal of Aviation Medicine*. A glance at the literature of aviation medicine indicates that the few items which appeared in this decade were the results of observations or studies made during World War I. Two important trends of development started during this period. Following the lead of Longacre at the Army School for Flight Surgeons, flight surgeons in the Army Air Corps and in the Navy began to experiment with the study of personality as a means of improving selection of prospective aviators. Mashburn, at the same school, developed a reaction-time apparatus. The former trend led to intensive studies in the field of pencil and paper psychological tests for selecting candidates for training. Mashburn's invention was followed by developments in the field of psychomotor tests (apparatus tests) for the same purpose. Both types of tests were to be used by the Army and Navy during World War II, with enormous savings of time, effort, and cost.

Aviation medicine appears to have received its first official recognition in the Navy in 1921, when five medical officers were ordered to the Army School for Flight Surgeons. One of these, Lieutenant Victor S. Armstrong, was ordered to the Naval Medical School at Washington to organize courses in aviation medicine. However, the Navy continued to send most of its prospective flight surgeons to the Army School until 1938. After completing the course of formal instruction at the Army School these medical officers were usually sent to Pensacola for a period of flight training and indoctrination.

The decade before World War II saw swift developments in the field of aviation medicine. To recount them adequately is beyond the scope of this book. It will be possible to indicate only the more significant.

General Armstrong has tersely outlined the developments in aviation to which aviation medicine made a large contribution: "From 1930 on, the developmental work of the military services, and the demand for larger, faster commercial planes, resulted in an increase in size, weight, speed, and maneuverability of aircraft to a remarkable degree. By 1939 aircraft engines were developing three times the horsepower that they had had only a few years previously. Operating speeds had changed from 100 to 200 miles per hour and military aircraft were attaining speeds in excess of 375 miles per hour. Commercial airlines were carrying thousands of tons of mail, freight, and express, and their passenger lists had passed the million mark in 1937."[2]

It now became evident that consideration of the human element in further developments of aircraft performance would require a lot of study. Planes were being built that were too much for the human being to handle. Cockpits were becoming too complex. Ceilings of operational altitude were such that better oxygen supplies and better protection from cold were essential. Accelerative forces were of such magnitude that thorough study was imperative. The problems of adapting man to his newest machine and of adapting the machine to man were legion. Research laboratories were required.

The first of these to be established in this new era was the Army Aero Medical Research Laboratory at Wright Field, Dayton, Ohio (1934). This laboratory has a splendid record of achievement. In 1939 the Navy established the Naval School of Aviation Medicine and Research Center at Pensacola, Florida. Two years later the Army Air Forces activated a research

section at its School of Aviation Medicine at Randolph Field, Texas.

Concurrently with these developments in the Army and Navy there evolved an increasing interest in civilian institutions. In 1938 the Mayo Clinic at Rochester, Minnesota, arranged to conduct annual physical examinations for pilots of some of the airlines. This activity developed into extensive researches, which culminated in the construction of a special research laboratory in 1942. In Germany, all medical students were receiving training in aviation medicine by 1938. In 1939 George Washington University established a graduate course in aviation medicine and the University of Cincinnati offered courses in the subject to undergraduate medical students.

With the advent of World War II an increasing number of medical schools began teaching in the field of aviation medicine, and many civilian medical research laboratories turned their attention and efforts to the study of problems in this field. Two committees of the National Research Council played important roles during this period: the committee on aviation medicine exerted considerable influence by stimulating research in civilian laboratories. The committee on selection and training of aircraft pilots actively directed an enormous amount of research in the fields delineated by its title. Some of this work was done at various universities but a good deal of it was done for the Navy at the Naval Air Station, Pensacola, Florida, in close cooperation with the Training Command and the Naval School of Aviation Medicine.

Much of the results of all this will appear in subsequent chapters, as will a good deal of what was learned by research during the Second World War. Most of the work done after the beginning of that war was classified and is only now being made public. It is generally appreciated that aviation medicine saw vast developments in that period, but the history of the period has not been written: we are too close to it.

NOTE:—Appreciation is expressed for the assistance of Dr. Dean Brimhall, Director of Research of the Civil Aeronautics Administration, for making available some of the original sources referred to in this chapter.

BIBLIOGRAPHY

1. Wilmer, W. H. *Aviation Medicine in the A.E.F.* Washington, Government Printing Office, 1920.
2. Armstrong, H. G. *Principles and Practices of Aviation Medicine.* Baltimore, Williams and Wilkins, 1943, Second Edition.
3. Birley, J. L. *The Principles of Medical Science as Applied to Military Aviation.* A lecture delivered before the Royal College of Physicians. *Lancet*, 29 May 1920.
4. Seibert, E. G. *Medical Studies in Aviation. Washington Medical Annals.* 18:46-49, 1919.
5. Jones, I. H. *Flying Vistas.* Philadelphia, Lippincott, 1937.
6. *Air Service Medical.* Washington, Government Printing Office, 1919.

CHAPTER 2

THE PROBLEM OF REDUCED BAROMETRIC PRESSURES*

The physiological effects of reduced barometric pressure, and the methods and means by which flying personnel are provided with a normal or near normal environment at high altitude, are briefly discussed in this chapter under the following subject headings:

1. The physics of the atmosphere.
2. Anoxia.
3. The expansion of body gases at altitude.
   a. Intestinal tract, middle ear, and paranasal sinuses.
   b. Aeroembolism.
4. Oxygen equipment in aviation.
5. Temperature variants in aviation as a problem.
6. Noxious gases in aviation.
7. Pressurized equipment and explosive decompression.

THE PHYSICS OF THE ATMOSPHERE

No adequate understanding of the function of the human body can be made without an understanding of its environment. This is particularly true in regard to an adequate understanding of the bodily reactions in flight.

The lower regions of the envelope of gases surrounding the earth make up the environment of all mankind; however, there is a special state of this environment for those who fly in the upper reaches of the atmosphere. It is for this reason that we shall discuss the atmosphere of the earth with respect to the physics of the air in relation to human physiology. We shall concern ourselves with atmospheric composition, pressures, temperature, and density at sea level and at various altitudes.

* Prepared by Cdr C. F. Gell, (MC), USN

The earth is surrounded by an envelope of a mixture of gases and water vapor, which is held close to it by the force of gravity. The depth of the mixture of the gases is quite variable, but it is generally considered to be, roughly, 100 miles. This layer of gases contains about 78 percent of nitrogen and 21 percent of oxygen, and the remaining one percent contains traces of carbon dioxide, hydrogen, helium, neon, argon, krypton, and xenon. We are primarily concerned with three components of the air exclusive of water vapor, namely, oxygen, nitrogen, and carbon dioxide. Each is important for a different reason. As you well know, oxygen is essential for the combustion of body fuels (foodstuffs) and the release of body energy. Nitrogen has no particular value for living processes, but is important because, as an inert gas comprising almost 80 percent of the atmosphere, it figures prominently in aeroembolism. The role of carbon dioxide is well known to you. It is insignificant in percentage of the atmosphere, but comprises about 5 percent of the expired breath. A definite amount of carbon dioxide is necessary in the blood for control of breathing and heart action, but too great a concentration in an air sample is incompatible with life.

The composition of the atmosphere has been evaluated by the collection of air samples by various means, including pilot balloons and high altitude aircraft flights, at altitudes ranging from sea level to 50 miles above. More recently the use of rocket missles for investigating the upper atmosphere has given us more extensive information. The lower portion of the atmosphere, being more easily analyzed, displays a constant percentage composition of

gases. Water vapor of the atmosphere varies in the cloud areas, but averages about 1.2 percent. The percentage of water vapor gradually decreases until the air above 35,000 feet is practically dry. This is evidenced by the lack of clouds in the stratosphere.

Briefly, we recall that there is a relationship between the volume, temperature, pressure, and density of a gas. To examine the atmosphere in respect to its pressure, temperature, density, and so on, it is important to review the *Gas Laws,* which are the physical laws to which gases conform in their behavior. Since air is a mixture of gases, its behavior will conform to the gas laws. Take a gas-filled cylinder with a tight-fitting piston; the greater the pressure exerted on the piston, the smaller the volume—and if heat is applied the gas will expand and occupy a greater volume. Of course, when pressure is reduced the volume is increased, and when the piston is cooled the volume is decreased.

In more technical language, we state the gas laws as follows:

1. When the *temperature* remains constant, *volume* of a gas varies inversely as the *pressure;* that is, the greater the pressure the smaller the volume and, conversely, the less the pressure the greater the volume (PV-P'V'(1)) is the form in which this law is stated by the physicist.

2. When the *pressure* remains constant, the *volume* of a gas varies directly as the temperature; that is, the warmer the larger the volume, or conversely, the colder the smaller the volume. (Physicists combine these as the gas law:

$$\frac{PV}{T} = \frac{P'V'}{T}.$$

3. Since the atmosphere is a mixture of gases ($O_2N_2CO_2NeKr$, etc.), another gas law, Dalton's Law, is relevant. It is the law of *partial pressures,* and states: The pressure of a mixture of gases in a given space is equal to the sum of the pressures which each gas of a mixture would exert by itself if confined in that same space. In other words, each gas in a mixture of gases exerts a pressure proportional to the percentage of the whole which it occupies.

4. Another characteristic of gases which is important, especially in understanding the physics of the air in regard to physiology, is density. Density of a gas is the weight of a standard unit of volume of gas, and can be visualized as the number of particles (molecules) per unit volume. The greater the density the greater the number of molecules per unit of volume. The density of air (dry) is 1.293 kg. per cu. meter. (A kilogram is equal to 2.2 pounds; a meter is roughly a yard.) This measurement must be made under standard conditions, 15° C. and 760 mm. of mercury pressure.

Bearing in mind the gas laws, and the fact that air is a mixture of gases, we will examine the atmosphere. Since air has density (weight) it exerts a pressure. In order to measure this pressure we employ a barometer.

A simple barometer is made by filling a glass tube, which is sealed at one end, with mercury, and then inverting the tube in an open dish of mercury, so that the open end of the tube is below the surface of the mercury in the dish. The column of mercury in the tube will fall to a height dependent upon the air pressure. At sea level (standard conditions) the column will be 29.92 inches, or 760 mm. high. In other words, the atmospheric pressure is great enough to support a column of mercury 760 mm. high. As a matter of fact, the weight of a column of air 1 inch square, from sea level to the uppermost reaches of the atmosphere, is about 15 (14.7) pounds. The weight of 14.7 pounds per square inch is designated as one atmosphere.

Let us return to our mercury barometer (there are other types, too) and start studying atmospheric pressure. If we begin a trip starting at sea level and climb up to a mountain peak, we notice that after we have climbed up 1,000 ft. the column of mercury has dropped (gradually) from 760 mm. to 732.9 mm. At 5,000 ft. above sea level the column is only 632.3 mm. At 10,000 ft. the barometric pressure has dropped to 522.6 mm. We see clearly that as the altitude increases the atmospheric pressure decreases.

This relationship has a significant and striking aspect; namely, at 18,000 ft. the pressure has been reduced to 380 mm. (1/2 atmosphere); at 34,000 ft., to 190 mm. (1/4 atmosphere), and at 42,000 ft. to 128 mm. (1/6

atmosphere), so that 5/6 of the atmospheric pressure (read density) is concentrated in the lowest 8 miles of the 100-mile atmosphere. With the decrease in barometric pressure as the altitude increases there is a corresponding decrease in partial pressure of oxygen. Eventually, the partial pressure of oxygen gets so small that sufficient oxygen necessary for life is not available.

This is true because the partial pressure of each component of a mixture of gases is the product of the percentage composition times barometric pressure, and while at sea level (760 mm. Hg.) the partial pressure of oxygen in atmosphere is 157 mm. (or an equivalent oxygen percentage of 20.93), at 18,000 ft. (380 mm. Hg.), the partial pressure of oxygen is 79.3 mm. (or an equivalent oxygen percentage of 10.45). Therefore, the passage through the lungs, into the blood, of the required amount of oxygen essential for living tissue is determined by the partial pressure of oxygen in the atmosphere, and cannot take place above certain altitudes. So, in order to maintain sufficient oxygen pressure, the percentage of oxygen in the inspired air must be increased ($P\ O_2 = \%\ O_2\ P$ Air), until finally 100% oxygen must be used at high altitudes.

The table shows the relationship between altitude, barometric pressure, oxygen pressure. and oxygen percentage equivalent.

Altitude *(Feet)*	Barometric Pressure *(mm. Hg.)*	Oxygen Pressure *(mm. Hg.)*	0_2 Percent Equivalent
0	760	159.0	20.96
3,281	670	140.4	18.40
6,562	593	124.5	16.40
9,842	524	109.8	14.50
10,300	506	105.9	13.00
16,404	410	85.9	11.30
18,000	380	79.5	10.00
22,966	320	67.0	8.80
28,000	253	53.0	6.90
34,000	187	39.0	5.16
40,000	149	32.0	4.20
42,000	128	26.7	3.52
50,000	90	18.8	2.40

The study of the structure of the atmosphere reveals an interesting relationship between the altitude and the air temperature. Roughly, there is a decrease in temperature of 2 C° for every 1,000-foot rise is altitude. This approximate relationship is true until 35,000 to 36,000 ft. is reached, whereafter the temperature remains rather constant, varying between —55° to—65° C. The *constant* temperature zone is called the stratosphere, and this region of the atmosphere is free from vapor (and, consequently, icing problems). The extreme cold of high altitude has a direct bearing on physiologic function and will be discussed later.

Below is listed information concerning varying altitudes:

Altitude	*Data*
380,000	Maximum rocket flight—normal trajectory.
360,000	Lower limits of the aurora borealis and australis.
300,000	"Shooting Stars".
270,000	Stratopause—lower limit of ionosphere.
250,000	Noctilucent clouds—upper limit of propagation of sound in air, since molecules are so rare and far apart.
132,000	Sounding balloon flight.
106,000	Maximum ozone concentration.
72,000	Record balloon ascent by Captains Anderson and Stevens.
63,000	Total atmospheric pressure 47 millimeters of mercury standard vaporization of fluids takes place.
34,000	Upper limit of normal oxygen saturation of blood breathing 100 percent oxygen.
32,000	Tropopause—average. Gasoline boils at —54° C.
30,000	Sky appears purple.
29,000	Peak of Mt. Everest.
18,000	Highest human community.
10,000	Level at which human begins to show signs of oxygen lack, breathing ambient air.

ANOXIA

Anoxia may be defined simply as a condition of oxygen deficiency in the human body. You are all familiar with the classical classification of the etiology of anoxia outlined as follows:

1. Anoxic anoxia.
2. Anemic anoxia.
3. Stagnant anoxia.
4. Histotoxic anoxia.

A more recently advanced classification has been promulgated by workers in this field, to point out more clearly the etiological factors responsible for anoxia. This classification is shown as follows:

1. Environmental anoxia.
2. Pulmonary anoxia.
3. Circulatory anoxia.
4. Histotoxic anoxia.

Both anoxic anoxia of the old classification and environmental anoxia of the new are descriptive of the etiology of the anoxia existing under conditions of decreased atmospheric pressure. There is simply not enough oxygen concentration in the environmental atmosphere to sufficiently oxygenate the arterial blood, resulting in an incomplete oxygen saturation of the hemoglobin.

The reduction of the arterial tension of oxygen is more serious than the lack of oxygen saturation. The velocity of oxidative processes has been determined by experimental methods to be proportional to the partial pressure of oxygen. Also, the increased respirations induced by this lowered oxygen pressure wash out the carbon dioxide of the arterial blood and, because of this fact, much reduce the dissociation of oxyhemoglobin. In fact, the tissues of the body are hampered in three ways in this type of anoxia: The rate of oxidation is diminished because of the lowered partial pressure of oxygen in the blood; there is less oxygen in the blood than normal; the low carbon dioxide pressure hampers the dissociation of oxyhemoglobin. This is the type of anoxia in which we are most interested in aviation, because it is this type which our flight personnel will have to combat and which we are attempting to help them overcome.

A further classification of anoxia of the anoxic or environmental type may be shown as follows:

Fulminating anoxia.—This is rapidly induced by sudden ascents to extreme altitudes without oxygen, as in explosive decompression, or in breathing high concentrations of inert gases, as sometimes happens in our dirigible crashes when personnel are caught in high concentrations of escaping helium gas. Unconsciousness may develop in 45 to 90 seconds. This type of anoxia resembles asphyxia, but asphyxia is not anoxia.

Acute anoxia.—The difference between this type and the above is that the acute anoxia is not developed as quickly and is not as severe. This is the type of anoxia which you see every day in the low-pressure chamber when the subjects are over 10,000 feet without oxygen. While every organ in the body is presumably affected in this type of anoxia, the central nervous system, the respiratory, and the circulatory systems appear to be affected the most. The nature of the effect of this type of anoxia will be studied in detail later.

Chronic anoxia.—This is a condition which results from long exposure to high altitudes, and even in the acclimatized individual there is a dyspnea on exertion. The symptomotology of this condition may be stated briefly as principally fatigue. Fatigue develops much faster than at sea level and recovery is much slower. This condition may also produce degenerative changes in some organs. Chronic anoxia is rarely seen in aviation because of the infrequency of exposure to predisposing factors and universal use of oxygen equipment.

The effect of anoxia on the blood has been studied for many years, and by many different investigators, and from this mass of work the following conclusions may be drawn. In acute anoxia, such as we are dealing with, there is some evidence that the number of red blood cells is increased rather rapidly in most subjects—in the matter of an hour or so—and probably as a result of contraction of the spleen forcing a larger number of the cells into the blood stream.

The effect of anoxia on the heart and circulation in acute anoxia results in the following changes in the blood vascular system. The pulse rate increases, as does the contraction of the heart, until the percentage composition of oxygen in the alveolar air falls to below 9 percent. After this critical level the rate may remain stationary or decrease, but the minute volume output of the heart rapidly falls until that time when the anoxia affects the heart muscle, when the rate falls rapidly and a circulatory collapse occurs.

There is no real evidence that the blood pressure changes to a significant degree. In cardiac failure one explanation is that the intramuscular pressure is responsible for the maintenance of venous pressure and, consequently, the venous return to the right side of the heart. In the circulatory collapse, according to this theory, the intramuscular pressure falls first, followed by the failure of the venous return and consequent deficient filling of the heart and decrease in the amount of blood the heart is able to put into circulation. This is

then followed by a fall in blood pressure, and the fast, thready pulse which we are so accustomed to seeing in shock. The pallor and sweating are a result of the contraction of the peripheral arterioles in an attempt to return the peripheral blood to the circulation.

The respiratory system is profoundly affected by lowered partial pressure of oxygen. There is a fall in the alveolar carbon dioxide pressure, which is due to the increased rate and depth of the respiratory movements. The increased rate and depth of respiratory excursions washes the carbon dioxide out of the alveolar air. This results in a fall of 4.2 mm. Hg. of carbon dioxide pressure for each fall of 100 mm. Hg. of barometric pressure. (This is disputed by some workers.)

In acute anoxia there is an increase in the rate, the depth, and the minute volume of the respiration. The respiratory center is evidently one of the most sensitive areas to the lowered oxygen partial pressure. It is believed by some workers that with the decrease in oxygen the respiratory center becomes more sensitive to the carbon dioxide; which would explain the increased rate and depth of respiration. After anoxia has progressed to the point where the cells of the respiratory center have a markedly reduced excitability, respiration may cease. Other effects on the respiratory system in acute anoxia are a slight depression of the respiration, while the body recovers from the loss of carbon dioxide and while the bicarbonate is being reformed in the blood. Some subjects, when in the stage of acute anoxia, show a change in the pattern of respiration, a periodic breathing which resembles the well-known Cheyne-Stokes Syndrome. The vital capacity is decreased approximately 10 percent at an altitude of 15,000 ft. This is probably due to the dilatation of the alveolar blood vessels.

Another system which alters its function during anoxia is the central nervous system. Nervous tissue is the least capable of withstanding oxygen want. In anoxic anoxia the blood vessels which supply the brain dilate early, but because of the lowered oxygen pressure the brain has a deficient oxygen supply. At a simulated altitude of 28,000 ft. experimental studies have shown cortical cell changes. Some of these changes may be irrevocable. Studies of the survival of nervous tissue completely deprived of oxygen, even for a matter of minutes, show the pyramidal cells of the cerebral cortex are most sensitive, the cerebellar cells next, followed by the medullary centers and spinal cord, in that order.

The spinal fluid pressure is increased, as is the intracranial pressure. The mechanism for producing this pressure is not known, but may be due to the increased permeability of the capillary walls.

The entire nervous system is affected in anoxia: the finer judgments and discriminations are lost first, followed by a train of events, such as increased reaction time, loss of initiative, and slowness of neuromuscular coordination. The after-effects of anoxia are headache, fatigue, and slow recovery of finer judgment sense. The other organs of the body are also affected, but the changes just examined become so profound that death would result before secondary changes.

The type of anoxic anoxia which is most common in aviation is, of course, that which is associated with altitude. The decreasing atmospheric pressure, with resultant decreasing partial pressure of oxygen in the inspired air, results in a lowered oxygen tension in the arterial blood. Obviously the degree of anoxia is directly related with the degree of lowered oxygen tension; which in turn is related to the altitude. At an altitude of 10,000 ft. there is a moderate or mild degree of anoxia which has no telltale effects for the first 4 or 5 hours. There are, however, definite subclinical effects and the finer, or higher, brain functions are dulled. With increase in altitude there is a more marked anoxia of such a degree that from 12 to 15 percent of healthy adult personnel will faint or become unconscious within a half-hour at 18,000 ft.

As far as aviation personnel is concerned, anoxia, even though it be of low grade and not severe enough to cause unconsciousness, is a very important condition. Low-grade anoxia will affect the nervous system, causing complete lack of critical judgment, a lack of motor coordination, and a false feeling of well-being.

Overcoming the effects of anoxia forms the basis of a very valuable practice in aviation medicine, namely, the utilization and training

Figure 2-1.—Demonstration of anoxia in a low pressure chamber at the Naval School of Aviation Medicine. The subjects are in an anoxic state at 18,000 feet. The subject to the left is apathetic. Center subject has fair control of his faculties. Subject on the right can no longer complete the co-ordination test.

in the use of accessory oxygen equipment at altitudes over 10,000 ft. The natural lowered partial pressure of oxygen is increased artificially by the use of such oxygen equipment. Thus, by the use of accessory oxygen equipment, aviation personnel can go from sea level to high altitudes day in and day out without any deleterious effects of anoxia.

The importance of anoxia in aviation is so great that it is worth our while to reiterate salient points in the above discussion. Aviators are required to use accessory oxygen equipment at all times when flying at or over 10,000 feet above sea level, except for short emergency periods. Anoxia becomes progressively more profound as we ascend above 10,000 feet, and at 15,000 feet the blood oxygen saturation drops off to as low as 77 percent, and rarely exceeds 87 percent. Within this range one finds considerable handicap in the performance of any physical or mental activity. Headache, slight dizziness, a slight feeling of nausea, sluggishness, and a general feeling of heaviness may be present; vision is slightly dimmed, and a feeling of confusion may exist. The individual is partially cyanotic; that is, the nails, lips, and

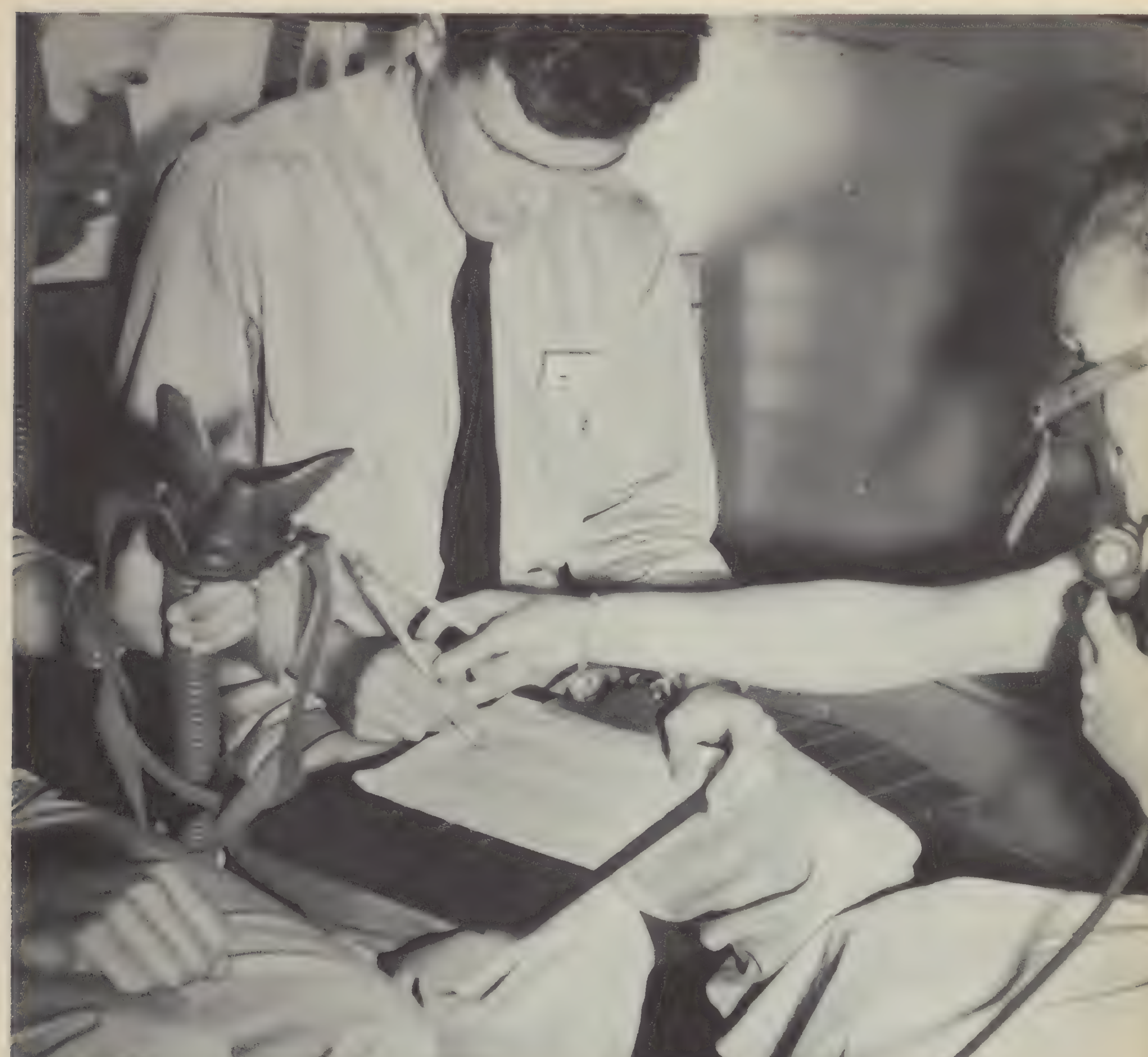


Figure 2-2.—Progressive anoxia at 18,000 feet. Demonstration in a low pressure chamber at the Naval School of Aviation Medicine. The subject no longer writes his name as instructed, but merely scribbles on the pad.

ear lobes may range from a light blue to a deep purple. As is true in all degrees of anoxia, judgment is impaired.

Above 15,000 feet symptoms of anoxia persist and may be intensified; the vision is further dimmed and the cyanosis is increased. The general feeling may be altered from that of weakness and sluggishness to a feeling of well-being and gaiety much akin to that associated with certain stages of intoxication. Progressive increase in anoxia results, of course, in severe taxing of the body with an increasingly degree of malfunction, weakness, stupor, coma and death.

An important condition associated with prolonged flying at 9,000 to 10,000 feet is the chronic low-grade anoxia. Flying personnel who experience long missions at an altitude of between 8,000 and 10,000 feet find themselves extremely fatigued, irritable, suffering from insomnia, loss of appetite, and a general insidious weakness. This picture does not present itself

Figure 2-3.—Demonstration of anoxia at 30,000 feet in a low pressure chamber at the Naval School of Aviation Medicine. Subject is increasingly dull and no longer recognizes the playing cards as he turns them over.

Figure 2-4.—Subject in low pressure chamber at the Naval School of Aviation Medicine wearing aviator's positive pressure oxygen breathing equipment. Type 13 mask, positive pressure regulator and bail-out bottle.

when personnel use oxygen on prolonged moderate altitude flights, since by using oxygen the accumulated effects of this low-grade, undetectable anoxia are prevented.

The most efficient method of increasing the altitude to which one may safely ascend is through the use of supplemental oxygen in the inspired air. This oxygen replaces a portion of the unnecessary nitrogen, thus increasing the oxygen percentage of the air inspired. Using one hundred percent of oxygen one is able to maintain a normal 96 percent oxygen saturation up to 34,000 feet. Beyond this altitude, total barometric pressure is so low that, regardless of the amount of oxygen in the inspired air, the partial pressure necessary to drive sufficient oxygen from the alveoli into the blood and maintain normal saturation is too small. At 42,000 feet, breathing pure oxygen, a man is approximately as well off as when he is at 18,000 feet breathing ambient air.

The recent introduction of pressure breathing equipment (figure 2-4) has increased the ceiling of the aviator to even greater heights. For many years most physiologists believed that under no circumstances must positive pressure be applied to the inspired air. It was believed that damage to the alveoli would inevitably result. Through actual experimentation in recent years by those engaged in aviation physiological research, it has been demonstrated that the average healthy young male adult can withstand positive pressure (to the extent of 10 to 12 inches of water pressure) for an indefinite period. As a result of these findings, positive pressure breathing equipment has been devised which permits an increased oxygen flow into the mask, and at the same time increases the resistance to the flow of expired air from the mask.

This system results in an increase in the oxygen pressure in the mask, which is transmitted through the respiratory passages to the alveoli, bringing about an increase in the oxygen transmission through the alveoli and a consequent increase in oxygen saturation of the arterial blood. Positive pressure oxygen equipment, properly adjusted, permits an individual to maintain an arterial oxygen saturation of approximately 87 percent at 43,000 feet, which is sufficient to maintain normal body functions. Above 43,000 feet even with 100 percent oxygen and pressure breathing, one rapidly becomes anoxic, due to an insufficient oxygen pressure in the inspired air. We may safely say, then, that the accessory oxygen equipment that is now standard in aviation, the absolute safe operational ceiling is 43,000 feet. The solution to further increased ceiling is the use of pressure cabins, cockpits, or suits.

EXPANSION OF BODY GASES

Gases in the body are present in free and dissolved states. Free gases are those present in such body cavities as the gastrointestinal tract, the paranasal sinuses, and the middle ear. The problem of the expansion of free gases in the paranasal sinuses and the middle ear is covered in the the chapter on aviation otorhinolaryngology. The expansion of dissolved gases in the body at altitude will be discussed under the subject heading of aeroembolism.

The gas found in the intestinal tract is largely that which results from the swallowing of air; however, some of it is produced by the decomposition of ingested food. The variable amount of gas present in the gastrointestinal tract is always maintained at a pressure approximately equivalent to that of the atmosphere surrounding the body. Intestinal gases, like all other gases, behave according to the gas laws. Therefore, as the individual ascends in the atmosphere, the volume of his intestinal gas will increase. It has been stated by Armstrong[1] that, because they are saturated with water vapor, the gases in the intestinal tract do not expand, (with ascent), in exact proportion to the decrease of barometric pressure; however, we can safely assume the change in relative volume at various altitudes as conforming to the following table:

Altitude	Relative volume of gas
0 ft.	1 volume
18.000 ft.	2 volumes.
28,000 ft.	3 volumes.
33,000 ft.	4 volumes.
38,000 ft.	5 volumes.
42,000 ft.	6 volumes.

The degree of difficulty encountered by the expansion of gases in the gastro intestinal tract

depends upon the amount of gas present and the rate of ascent.

If the ascent does not exceed 300 feet per minute, there will be only a feeling of moderate abdominal distention at 12,000 to 16,000 feet, with associated sensations of the movement of gas. Belching and the passage of flatus will begin and tends to continue as the altitude increases. Slow ascent rarely causes incapacitating abdominal discomfort, inasmuch as the expanded gases can be passed through the tract and eliminated. With rapid ascents of 2,000 feet per minute, or more, the gas expands rapidly and tends to remain localized in the intestinal loops—thus increasing abdominal distention—and abdominal cramps of varying severity may be experienced. The abdominal distention may also be great enough to cause upward pressure on the diaphragm and embarrass respiration; it may be of such severity as to distract the man from his task or incapacitate him. A primary type of shock, caused by pain stimuli from abdominal distention, has been observed in the operation of low-pressure chambers.

A major factor determining the amount of gas in the intestinal tract is the quality and quantity of food ingested. The following is a list of "Diet Don'ts" for flying personnel, particularly before engaging in high altitude flights:

1. Don't gulp food or fluid.
2. Don't eat excessively.
3. Don't eat gas-forming foods, such as beans, cabbage, raw apples, cucumbers, greasy meats, and spice.
4. Don't drink carbonated beverages, such as coca colas, gingerale, etc., or whipped drinks, as malted milks, milk shakes, etc.

In mild cases, passage of gas, or descent will ordinarily relieve the distress immediately. In severe cases, it is not unusual for the cramps to last for 24 hours after descent to sea level pressure. Vague, undefined gastro-intestinal complaints, (with the attendant abdominal distention), have been described as a result of repeated ascents.

AEROEMBOLISM

The tissues of the body contain a quantity of dissolved gas, held either in a physiochemical combination with certain elements or in a pure physical state. There are three main dissolved gases in the human body: oxygen, carbon dioxide, and nitrogen. Oxygen and carbon dioxide are found to be held both in physical and chemical combinations, with the greatest amount being bound chemically. Nitrogen, being an inert gas, is held in solution in the body purely by physical pressure. Since nitrogen constitutes approximately 80 percent of the gas dissolved in the body tissues, and since the amount varies with changes in the gaseous tension of the environmental air, this gas is most important in the problem of dissolved gases in the body when large changes in atmospheric pressure occur.

In discussing the cause of this condition it is helpful to use an analogy. Almost everyone is acquainted with the machine that makes the common soda water in soda fountains. It consists essentially of a cylinder with piston, ordinary water, and a tank of compressed carbon dioxide. Water is put in the bottom of the cylinder and some of the carbon dioxide is allowed to flow into the space above the water. The piston is then depressed, and with the increase in pressure the carbon dioxide dissolves in the water. As long as this pressure is maintained, the carbon dioxide will stay in solution. However, if the pressure is decreased, either by lifting the piston or by letting the soda water flow into the outside air, the carbon dioxide comes out of solution. This release of pressure is what accounts for the formation of bubbles, and the foaming up of carbonated drinks, when the bottle cap is removed. Now, how does this apply to the human body?

The human being lives constantly in an atmosphere made up of 80 percent nitrogen and 20 percent oxygen, at a total atmospheric pressure of about 15 pounds per square inch. Using our example above, we may compare the human body with the water in the bottom of the cylinder, and replace the carbon dioxide with the nitrogen and oxygen of the atmosphere. The "piston" (atmosphere) is set to exert 15 pounds of pressure per square inch. Under this pressure a certain amount of nitrogen and oxygen is dissolved in the human tissues, in a manner similar to the solution of carbon dioxide in water. Since the body uses the oxygen in

metabolic processes there is little of this gas existing in the free and uncombined form.

Insofar as the body is concerned, nitrogen is an inert gas and exists in the dissolved, uncombined form. As the body is taken to altitudes where the absolute pressure of the atmosphere is decreased or, as in our analogy, the piston is raised, the nitrogen comes out of solution from the body tissues and fluids in the form of nitrogen bubbles. (Thus, at sea level pressure, the tissues of the body are always saturated with atmospheric nitrogen.) It is of interest that nitrogen is more soluble in fats and oils than in water and, likewise, in the body the fats dissolve five to six times as much nitrogen per unit of mass as does the blood itself.

The following is the sequence of events in aeroembolism. During ascent in aircraft, or in any other situation in which the atmospheric pressure is decreased, the partial pressure of the body nitrogen is greater than the partial pressure of the alveolar nitrogen. The nitrogen from the blood diffuses into the alveoli of the lungs; the nitrogen of the tissues enters the blood stream, and thence into the lung. Thus, the body tends to rid itself of its excess (expanded) nitrogen. If the ascent is slow, and the nitrogen in the body can be eliminated through the lungs as fast as it comes out of solution, no unusual symptoms occur. If, however, the pressure is decreased rapidly to at least one-half the original pressure, the nitrogen gas will come out of solution with such relative rapidity that bubbles will form in the tissues, blood, and body fluids. The most likely site for bubble formation is body tissue, which has high fat content and meagre capillary circulation. When bubbles become large enough they block off capillaries, which causes a decreased local blood supply. This blocking of blood circulation interferes with the normal functioning of the local parts, and provokes various symptoms.

The symptoms of aeroembolism are conveniently grouped according to the affected site, as follows:

1. Skin and mucous membranes.
2. Bones and muscles.
3. Respiratory system.
4. Semicircular canals.
5. Central nervous system.

The skin and mucous membrane symptoms are popularly known as "The itch". These symptoms may be classed as paraesthesias, and presumably are caused by collections of nitrogen bubbles beneath the skin which irritate the sensory nerve endings. These symptoms manifest themselves in various ways. There may be a sandy sensation between the eyelids and the eyes. Frequently small bubbles may be seen beneath the conjunctiva. There may be sensations of cooling or drying of the eyes. A generalized itching of the skin may occur, but it is more common for one area, (usually near a large, subcutaneous deposit of fat, as around the waist or on the buttocks) to be affected. Scratching is only of temporary relief, since the nitrogen bubbles are pushed from one area to another. The sensation of ants crawling over the body is not uncommon. The sensations of excessive sweating when in reality the skin is perfectly dry, and of hot and cold flashes, also fall in the general group of paraesthesias in aeroembolism.

In some individuals, bubbles of varying sizes may be felt or seen beneath the skin and mucous membranes, particularly beneath the palmar skin of the fingers and beneath the ocular conjunctiva. In most cases the symptoms disappear immediately upon reaching lower altitudes (increased external pressure). A small percentage of cases retain subcutaneous induration and erythema for several days. None of these symptoms is incapacitating, but they are annoying. The occurrence of these dermal symptoms indicates the onset of aeroembolism, and should warn of the possibility of the development of more severe symptoms.

Symptoms of the joints and muscles are commonly referred to as "the bends". Some observers believe the pain in the bones and muscles is due to the blocking of capillaries supplying the area involved, while others believe it is due to the gas (nitrogen) pressure on or under the periosteum or the insertion of tendons about the joint. While movable joints are most commonly affected, pain is frequently felt in the region of the biceps and the posterior thigh muscles. The pain has been grouped into four arbitrary types, as follows:

Type 1. An aching in one or more areas, which is noticeable but not severe or incapacitating.

Type 2. Pain is more severe than type 1, and of such a degree that the subject restricts his movements. Although this pain is not incapacitating it definitely lowers a man's efficiency.

Type 3. Pain is more severe than type 2. The person is unable to move the member affected; he becomes pale, clammy, and if not relieved will become unconscious. It is definitely incapacitating.

Type 4. Pain appears with dramatic suddeness, and is very apt to render a man unconscious in a very short time, unless he is given immediate relief.

The bone and muscle symptoms are the most common causes of incapacity from aeroembolism. It is obvious that a pilot or crew member who is unable to move his leg or arm is a serious handicap to any mission. Descent to low altitude (greater pressure) effects immediate relief in most instances. Although there may be some residual effects after recompression they are not common.

The involvement of the lungs in aeroembolism, popularly known as "the chokes", is due to the collection of nitrogen bubbles in the circulation of the lungs. These bubbles irritate the mucous membranes of the respiratory tract and cause burning, substernal pain, an unproductive and difficult cough, and a sensation of choking. The "chokes" have also been described as "like mixing a bromoseltzer in the lungs." The symptoms increase the individual's apprehension, and may lead to collapse. It is definitely incapacitating and relief must be provided as soon as possible to prevent serious results. Fortunately, the "chokes" are much less common than the two groups of symptoms described above. Immediate relief without residual effect is gotten by descent.

A condition, popularly known among deep sea divers as "the staggers", may occur in aviators. The individual is completely confused in regard to position and movement, and behaves, accordingly, much like an intoxicated person. This condition is very incapacitating and the symptoms may persist for days, but fortunately its occurrence is rare in aviation.

Divers' "paralysis" is probably due to the blocking of cerebral or spinal capillaries, with a resultant ischemia to a certain area of the brain or spinal cord. Some believe it may be due to the direct pressure upon the nerve roots of nitrogen bubbles in the spinal fluid. It will result in paralysis of that part of the body controlled by the part of the brain or cord affected. Nitrogen bubbles have frequently been demonstrated in the spinal fluid at altitude pressures equivalent to that found at 18,000 ft. Since the spinal fluid has no direct connection with the circulating blood it is probable that the nitrogen is not rapidly eliminated. This has led some investigators to believe that most of the symptoms are due to pressure (from these bubbles) on the central nervous system. Fortunately, divers' paralysis is extremely rare in aviation.

In the early days of high altitude bombing in the last war, a fairly large percentage of the bombers had to return to these bases without completing their mission, because personnel developed incapacitating symptoms of aeroembolism. There were three methods open to correct this situation: the service could employ men for high altitude flying who were resistant to the effects of low atmospheric pressures (bend resistant); the physico-chemical state of the body of those who were susceptible to aeroembolism could be altered to render them less susceptible; or, the environment of the individual could be controlled so that he would not be exposed to low pressures, even though flying at high altitudes.

To aid in the selection of bend-resistant personnel, low pressure chambers were operated for the classification of individuals according to their ability to withstand the effects of low atmospheric pressures, with particular reference to the development of the symptoms of aeroembolism. Composite test data revealed that the younger the individual the less susceptible he is to the bends. Men in the older age groups, who have their valuable experience, need not, however, be eliminated from high altitude flying (except fighter craft), since by altering the physico-chemical state of the body a person can become more resistant to bends.

By breathing 100 percent oxygen, the partial pressure of alveolar nitrogen is greatly reduced,

with a resultant diffusion of nitrogen from the blood and tissues and a reduction of the nitrogen stores of the body. This is the principle of the process of *denitrogenation,* or, as it is sometimes called *preoxygenation.* According to the best available evidence, the elimination of about 50 percent of the body nitrogen before ascent to high altitude gives most people protection from serious or incapacitating symptoms of aeroembolism. Fifty percent of the body nitrogen can be removed by breathing 100 percent oxygen for one hour.

Since denitrogenation also occurs during ascent to high altitudes, and when 100 percent oxygen is breathed from the ground on up, the degree of nitrogen removal is greatly increased.

Denitrogenation, however, is practical in only certain types of combat flying, namely, scheduled missions. Bombing and observation plane personnel who are scheduled to fly at a certain time can begin breathing oxygen long enough before that time to insure sufficient denitrogenation. Fighter pilots, however, who may have to fly at any time, and who must climb at maximum rates, find denitrogenation impractical, since it would entail their breathing oxygen for long hours while at the *ready.* Therefore, for fighter pilots the first and third alternatives only are applicable, that is, choice of personnel or alteration of environment.

By maintaining the body within an atmospheric pressure more nearly that at sea level, even though the plane may be flying in a very high altitude, the development of aeroembolism can be prevented. That, of course, is the principle applied to the use of the pressure suit or the pressurized cabin plane. However, neither method is sufficiently developed at present to be practical for large scale combat flying.

Although it is known that nitrogen bubbles form in the tissues, and in the spinal fluid at 18,000 ft., it is rare to encounter any symptoms considered incapacitating below 30,000 ft. Practically, then, so far as aviation is concerned, aeroembolism is a disease that occurs only above 30,000 ft.

The probabilities of developing symptoms depend upon the rate of climb to the altitude and the length of time at that altitude. (Thus, a person might be able to tolerate 35,000 ft. for an hour, and yet become incapacitated with bends after 1 hour and 5 minutes. Also, an individual might be able to tolerate 35,000 ft. for several hours and yet develop incapacitating symptoms shortly after reaching 40,000 feet.) They further depend upon the amount of muscular movement, and the degree of protection from cold. Too much movement, and chilling both abet the onset of the bends. The general physical condition, with special regard to fatigue, alcohol, and food, is also a factor.

OXYGEN EQUIPMENT IN AVIATION

The development of oxygen equipment in aviation has kept pace with the constant improvement of design in modern aircraft. The picture in the past has been one of continuously increasing efficiency and ceiling in aircraft, with a concurrent intensification of physiological difficulties requiring further improvement in oxygen equipment. The lack of physiological data necessary for the development of aviators' oxygen equipment in the earlier days proved a major difficulty to flight surgeons and others engaged in aeromedical work. It is only in recent years that sufficient knowledge has been accumulated of the requirements of man at altitude, and that fairly satisfactory accessory oxygen equipment has been developed.

The first oxygen equipment used at altitude was that taken along by Tissandier, Croce, and Sivel in their historic balloon flight. This consisted of a container of oxygen with a tube and mouthpiece attached. The deficiency of this equipment was quite apparent for Tissandier's companions succumbed to anoxia. This tragedy of insufficient knowledge and unsatisfactory oxygen equipment has recurred many times in aviation since then.

The earliest standard oxygen equipment used by the Navy consisted of a high-pressure cylinder containing oxygen at 1,800 lbs. per square inch, with a reduction valve (that reduced the high pressure to 50 lbs. p.s.i.) leading to a pipestem through a rubber tube. This type of oxygen supply was very wasteful and, in general, unsatisfactory. Inasmuch as only a very small fraction of the oxygen was used in actual respiration, and because the oxygen

flowed constantly during the expiratory as well as the inspiratory phase of respiration, the oxygen was depleted rapidly at altitude. The pipestem itself was messy and the method promoted undue salivation. Earlier aviators referred to the pipestem as the "slobber tube."

Later, in an effort to render the oxygen system more economical and sanitary, a face mask was devised (replacing the pipestem), and a reservoir breathing bag was introduced for economy. This rebreather conserved the oxygen breathed out from the upper respiratory dead air space and so created greater economy. Until better equipment was developed it served aviation during the early part of World War II as an oxygen-administering device.

Another modification of the constant flow principle has been made by using a reservoir system composed of a series of check and relief valves. By this method, oxygen can be trapped in a reservoir during the expiratory phase of respiration, and then can be used as a source of supply during inspiration, resulting in greater economy.

The constant flow system of oxygen supply is more economical at increased altitudes, and so the rate of flow of such a system must be calibrated with that in mind. This is an application of Boyle's Law. As pressure drops with increasing altitude, the oxygen released occupies a greater space because of the decrease in atmospheric pressure. The increase in volume of the gas, with a drop in ambient pressure, alters considerably the minute volume respiratory requirements. Thus it is seen that a respiratory pattern at altitude, compared to a similar pattern at sea level, will actually receive an increasingly reduced quantity of oxygen (although the sea level volume requirements will be constantly met), since the oxygen expands when released at ambient pressures.

As the economy of oxygen became more and more important, it was necessary to find new methods of administering oxygen. This was necessary because of the weight and space occupied in aircraft by oxygen equipment. Both of these factors were and still are critical in aircraft design. Two types of apparatus were designed to increase the factors of economy. One was called the rebreather. This device is a closed circuit oxygen system similar to that used in a basal metabolism machine, and practically the only oxygen used by the wearer of this device is that which he actually consumes in his body. The chief difficulty with such a device (which proved to be its downfall in aviation) was the danger of air entering into the system, and the accumulation of carbon dioxide within the rebreather. Although this device offers the greatest economy, the dangers in its use were such that its military application was obviated.

The other alternative in increasing the economy of oxygen supply systems for aviators was to make a device which would administer oxygen only during the inspiratory effort, and only in sufficient quantity to keep the individual normally supplied with oxygen. This meant the development of a *demand* type of system which caused the oxygen to flow during inspiration only. Since the demand-type system furnishes 100 percent oxygen at all altitudes, there was still considerable wastage of oxygen.

To correct this waste factor a device was incorporated in the demand oxygen regulator permitting air to be sucked in and mixed with the oxygen in varying amounts, depending upon the altitude. This meant the development of an automatic control for diminishing the air dilution and increasing the oxygen percentage as altitude was gained, and a reserve procedure as altitude was lost. Such a device was developed and used by the Army Air Forces and Navy aviation during the greater part of World War II. This device is still being used, but has been modified several times to improve it functionally, decrease its weight, and increase its reliability.

The standard aviators' oxygen breathing equipment used in the Navy at present is a system utilizing a diluter-demand regulator at ambient pressures, and a system that will, when necessary, deliver oxygen under positive pressure.

The diluter-demand system as now used in the Navy (figure 2-5) consists of a high-pressure oxygen cylinder supply, connected to a diluter demand regulator that has a reduction valve as one of its integral parts. The regulator is designed for use in high altitude flight. It automatically mixes varying quantities of air

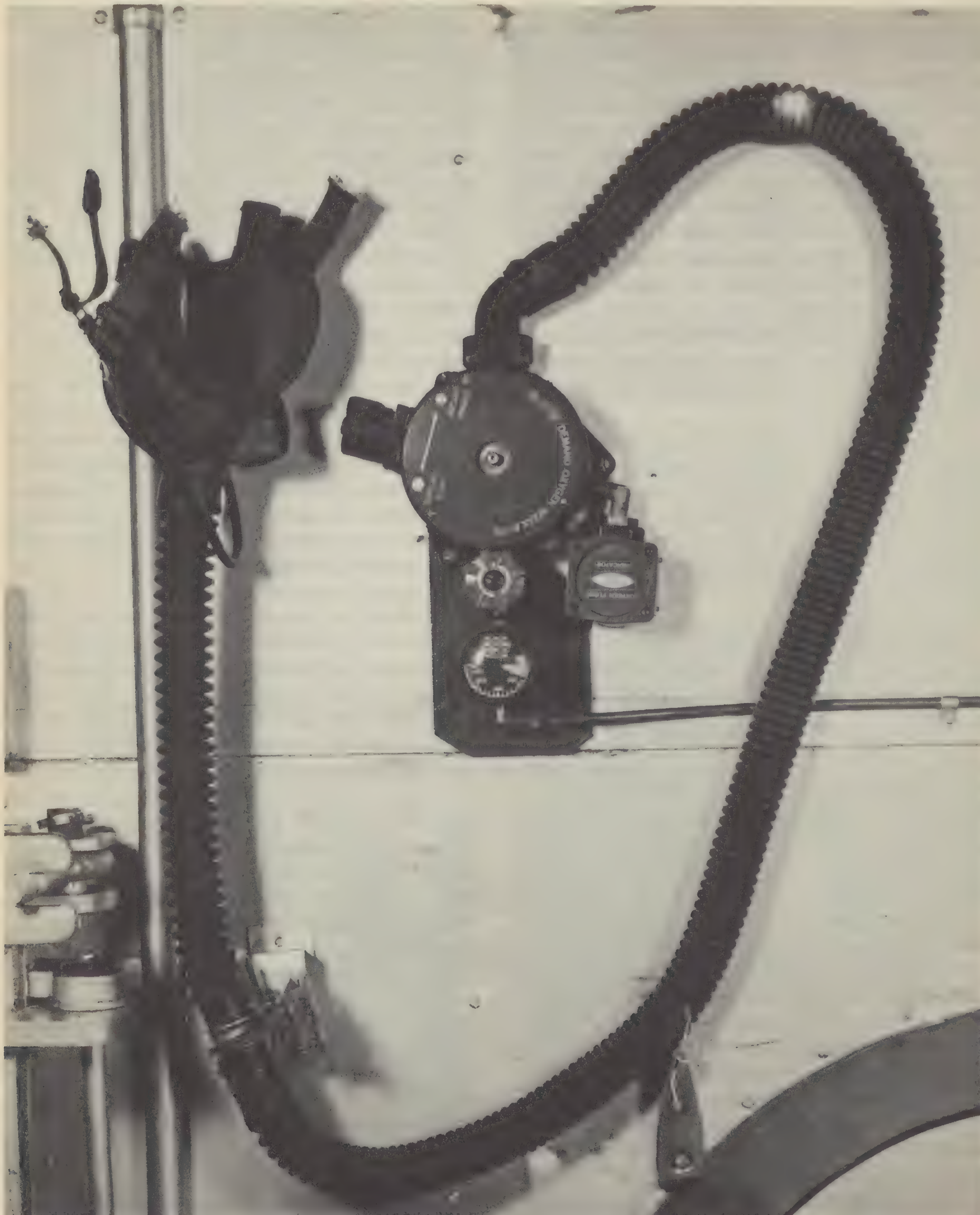


Figure 2-5.—Diluter-demand regulator, oxygen flow indicator and pressure gauge, with type 14 mask attached to quick release disconnect.

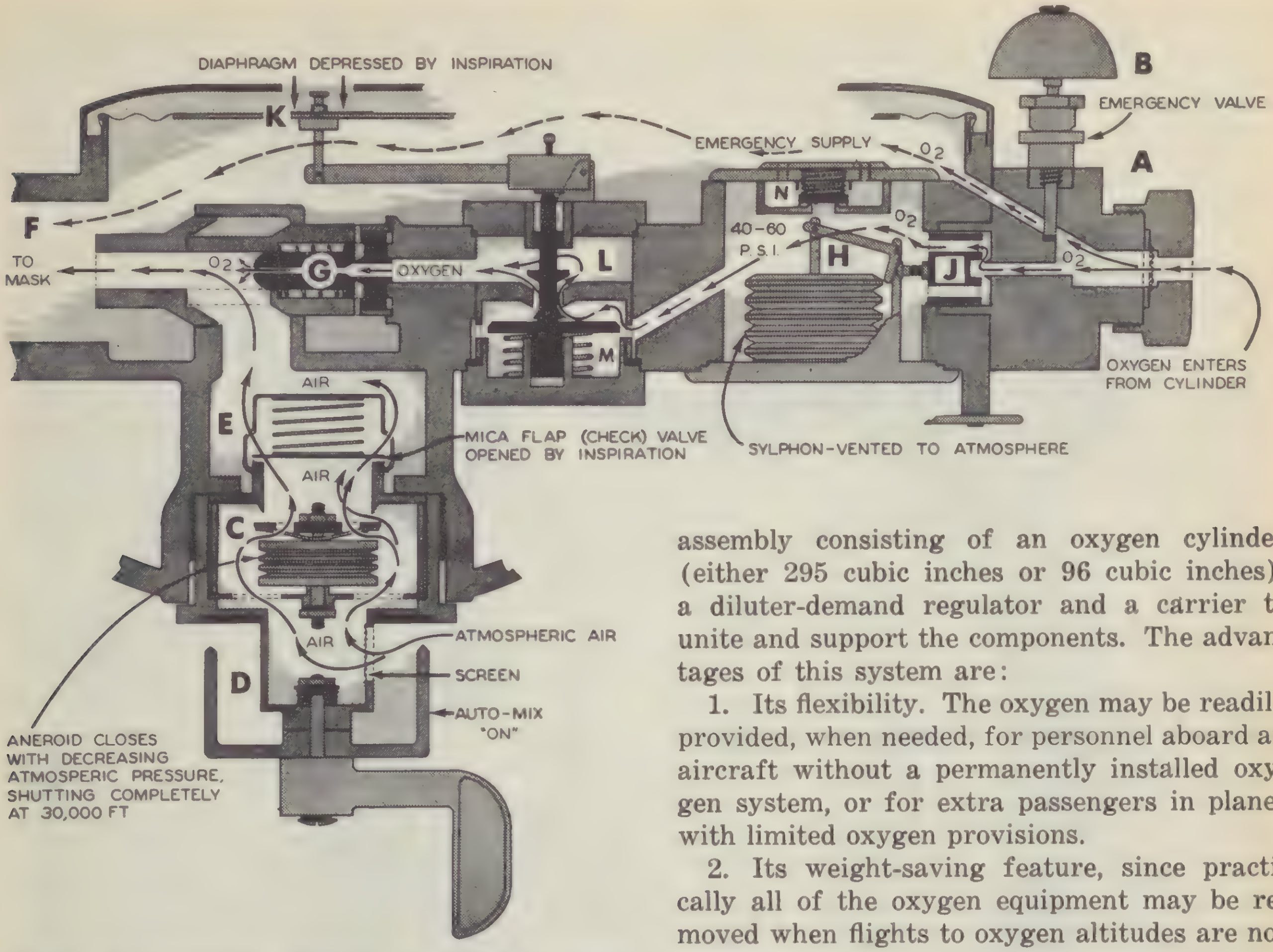


Figure 2-6.—Schematic diagram of a diluter-demand oxygen regulator.

and oxygen, the ratio depending on the altitude, and delivers the quantity demanded upon inhalation. The mixing device may be cut out and 100 percent of oxygen delivered on inhalation, or the entire valve may be by-passed by an emergency by-pass and 100 percent of oxygen delivered at a continuous rate. The diluter-demand type delivers oxygen at the ambient air pressure; therefore, above 30,000 feet, 100 percent oxygen.

The standard Navy mask used with this type of equipment is the type 14 oxygen mask.

In certain passenger, cargo, bomber, and patrol airplanes, there is a definite need for an individualized oxygen system utilizing the standard diluter-demand oxygen regulator, and permitting rapid installation and removal where flights to oxygen levels are made only occasionally. There is available a compact assembly consisting of an oxygen cylinder (either 295 cubic inches or 96 cubic inches), a diluter-demand regulator and a carrier to unite and support the components. The advantages of this system are:

1. Its flexibility. The oxygen may be readily provided, when needed, for personnel aboard an aircraft without a permanently installed oxygen system, or for extra passengers in planes with limited oxygen provisions.
2. Its weight-saving feature, since practically all of the oxygen equipment may be removed when flights to oxygen altitudes are not contemplated.

As has been previously stated, it is necessary to breathe oxygen under pressure if altitudes of 43,000 feet are to be reached and if the flier is to be normally supplied with oxygen. Pressure-breathing modifications were incorporated in the basic demand regulator, as well as in the oxygen mask: they included the construction of a constant flow attachment in the regulator, for use above 34,000 feet, and a variable resistant expiratory valve in the mask. Modifications are still being made in the present day pressure-breathing oxygen equipment. Even with the use of pressurized cabins and cockpits, it is necessary to equip aircraft with oxygen equipment, to be used as a safety device should pressurization suddenly be lost at high altitudes, and to permit lower pressurization.

The positive pressure demand oxygen system used in the Navy consists of the following articles, (figure 2-9); namely,

1. Type 13 oxygen mask.

Figure 2-7.—Type 14 oxygen mask for use with standard diluter-demand aviator's oxygen equipment.

2. The positive pressure demand oxygen regulator with the attached bail-out interlock.
3. The high pressure oxygen reducer.
4. The bail-out assembly.

The type 13 oxygen mask (figure 2-10) differs from the type 14 oxygen mask (now in current use in the Navy) in its method of suspension and also by having oxygen inlet check valves and a compensated exhalation valve.

The two inlet check valves are small rubber flapper valves placed over each of the oxygen inlet ports. These valves function in such a manner that upon exhalation they are closed, thus shutting off the flow of oxygen into the mask from the regulator.

The compensated exhalation valve is a valve

which permits exhalation from the mask. This valve is so designed that, in ordinary demand use, upon exhalation the valve opens, allowing the gases to escape from the mask through the exhalation port, as in the ordinary demand oxygen masks. When positive pressure is being used this valve, through a communication with the oxygen inlet tube, requires the wearer to exert (during exhalation) a slightly greater amount of pressure within the mask than the

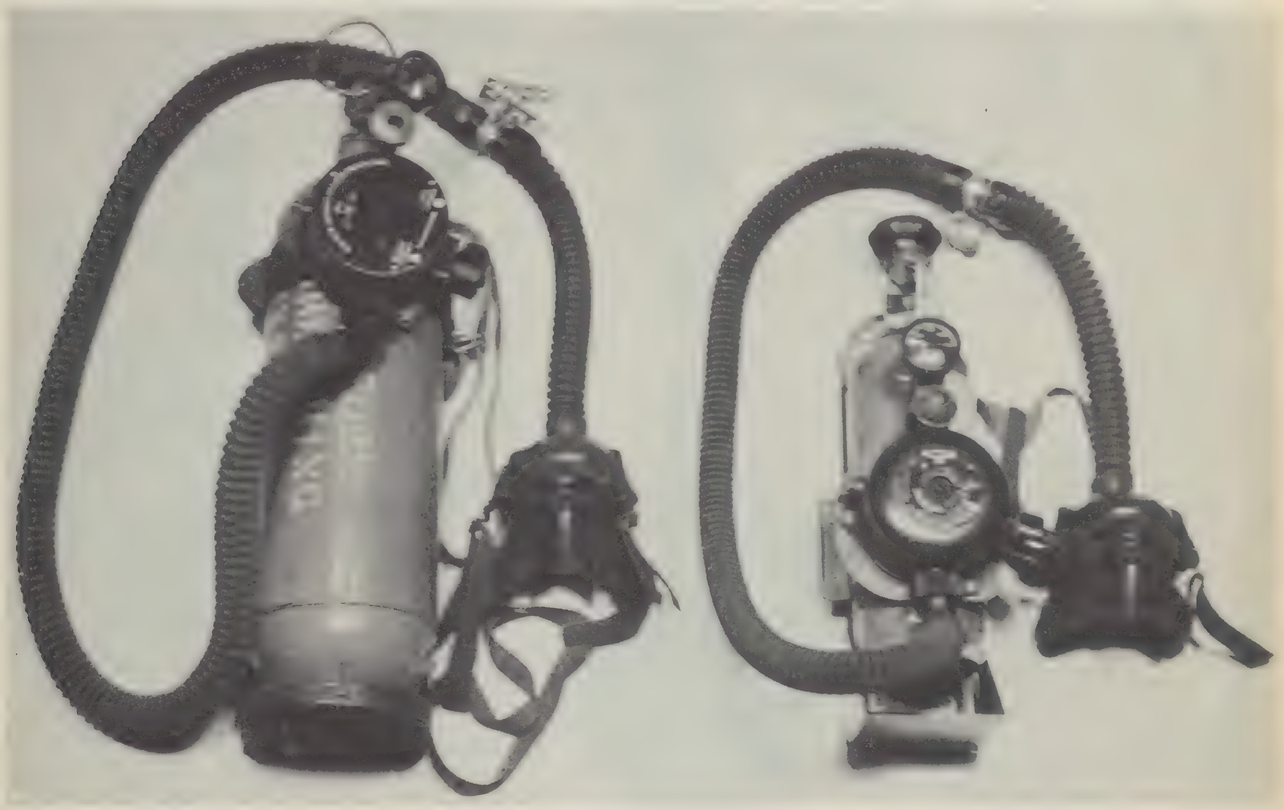


Figure 2-8.—Standard Navy Aviator's portable oxygen equipment, 205 cu. inch and 96 cu. inch oxygen bottles.

positive pressure being delivered to the mask by the regulator. In this manner the pressure in the mask is kept fairly constant both in inhalation and upon exhalation.

The positive pressure demand oxygen regulator (figure 2-9) is a chest-worn type of regulator and acts as any other demand regulator if the pressure setting on the dial is maintained at the *off* position. It will be noted that on the control knob of the regulator there is a scale which gives pressure settings for certain altitudes. These regulator settings deliver pressures to the mask and lungs as follows:

Regulator Setting Thousands of Feet	Pressure Inches of Water
35	1
40.5	2
41	4
41.5	6
42.5	8
43	10

These settings should be used at the altitudes indicated, and if the pilot does not feel properly protected with this pressure setting he may increase the setting to the next higher setting. This regulator is suspended from the neck by an adjustable strap, and this strap should be so adjusted that the smaller strap at the bottom of the regulator may be placed around the cross-chest strap of the parachute harness. In this manner the regulator is kept from swinging around the body, on movement. It should be remembered that when the dial reads in the *off* position the regulator functions as a normal demand oxygen regulator.

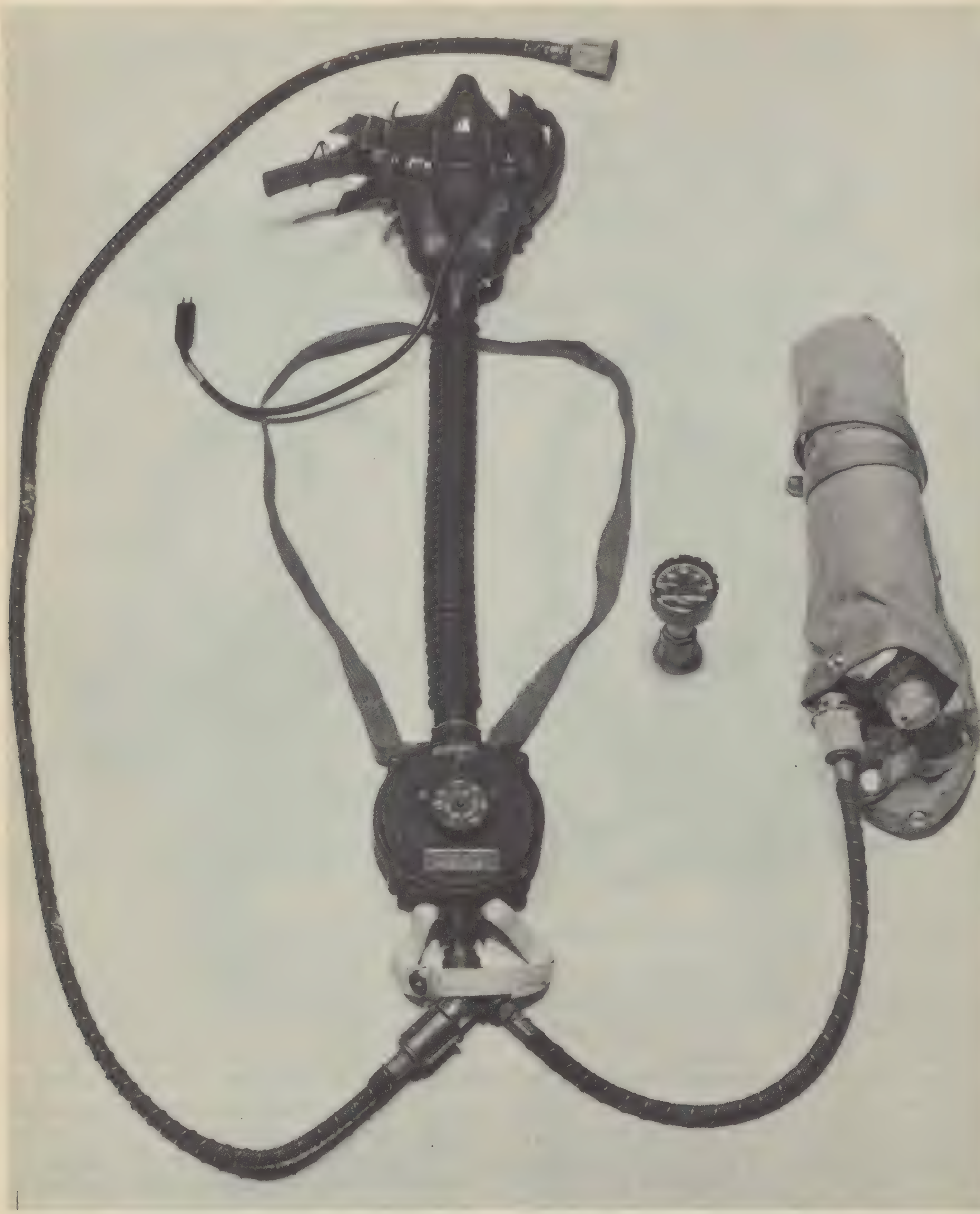


Figure 2-9.—Navy positive pressure oxygen breathing equipment for high altitude use. Equipment consists of the type 13 oxygen mask, positive pressure regulator, bail-out bottle and test valve for the bail-out bottle.

Figure 2-10.—Type 13 oxygen mask for use with positive pressure oxygen systems for aviators.

Attached to the bottom of the regulator is the "bail-out" interlock assembly. This interlock permits disconnection of the regulator from the oxygen supply of the plane; upon such disconnection the "bail-out" cylinder automatically provides oxygen, without necessity for any other action on the part of the pilot. In other words, by merely disconnecting from the airplane supply the flow is continued automatically from the "bail-out" cylinder.

The "bail-out" bottle assembly (figure 2-9) consists of a 30.5 cu.in. bottle containing oxygen at 1,800 p.s.i., a reducer and a high pressure gauge, and also a quick disconnect fitting. The entire assembly described is held in a container which permits carrying of the assembly on the thigh.

Because there are hazards in the use of oxygen equipment, certain precautions must be taken to avoid its faulty operation. It is necessary that the oxygen be dry, for if it were moist condensation might take place in the fine orifices of the oxygen regulator; and since the upper atmosphere is cold, freezing might take

Figure 2-11.—Navy high pressure oxygen bottles for use in aircraft oxygen systems. Bottles are 504 cu. inch, 205 cu. inch and 96 cu. inch capacity.

place with a cessation of oxygen flow through the regulator. There is also considerable condensation of moisture from the expired air which collects in the oxygen mask. This condensation, at low temperature, might cause the masks to freeze and thereby close the inlet orifices, stopping the oxygen flow from the regulator into the mask. The expiratory valve might also freeze, preventing exhalation of air from the mask.

The mask must also be properly fitted to the individual face, to avoid the danger of inboard

leakage of outside air into the mask; this would dilute the oxygen concentration of the inspired air. Such inboard mask leakages are not important until an altitude of 30,000 feet has been reached. Since the total atmospheric pressure, and hence the partial pressure of oxygen, becomes so low at altitudes in excess of 30,000 feet, any dilution with outside air would prove dangerous. Oxygen regulators must be carefully checked, at frequent intervals, to insure their delivering the proper concentrations of oxygen at all altitudes. Care must also be exercised in the upkeep of the mask. The mask should always be kept clean, and should be replaced when it has lost its original shape and proper fit.

We have spoken only of one type of oxygen source being carried in aircraft, that of gaseous oxygen under high pressures in metal cylinders (figure 2-11). The standard Navy high-pressure cylinders are shatter-proof, as demonstrated throughout the War. The Air Force uses low-pressure containers of the magnitude of 400 to 500 pounds p.s.i. in shatter-proof bottles. These have the advantage of lightness, but are considerably greater in volume. There is another source of oxygen, for use in aircraft, which permits both economy and a decrease in space and weight of the oxygen source. This is oxygen in liquid form, which can be readily converted into gaseous oxygen in an airborne converter and then conveyed through the usual oxygen systems to the regulators. Since one liter of liquid oxygen, when converted, will furnish 800 liters of gaseous oxygen, considerable space and weight may be saved by using it.

The development of liquid oxygen has not yet reached the stage where it is practical for use in all aircraft. Its tendency to "flash off" while stored in a converter causes considerable loss of oxygen, whether the system is in use or not. In its present stage of development it is most suitable for the multiengine type of aircraft. If the handling of the liquid oxygen can be timed so that it is placed in the aircraft converter just before the take-off, then one could take advantage of its space, weight, and duration economy.

TEMPERATURE VARIANTS IN AVIATION AS A PROBLEM

The temperature range to which a man may be subjected, when flying at various altitudes and in different climates, may extend from 140° to minus 70° F. Since the production of heat and the regulation of body temperature are essential for normal living, environmental temperature becomes of great concern in aviation.

As stated earlier in this chapter, there is a decrease in temperature of 2° C. for every 1,000 foot rise in altitude until the 35,000 foot level is reached, whereafter the temperature remains rather constant, varying between—55° to —65° C. The problem of cold, therefore, becomes a real one when flying at extreme altitudes. The loss of heat to the human body occurs through the physical means of radiation, convection, and conduction, and a small amount through respiration. The heat loss rate is frequently accelerated by wind blasts from open hatches or ports in the aircraft. The proper use of clothing is man's main method for controlling heat loss. Because of the above-mentioned factors and because of the wide range of temperatures encountered in aviation, adequate clothing for flying personnel is an important consideration. There are two types of clothing worn by aviation personnel. One is the unheated, heavy, bulky type, which has both good and bad points. It requires no source of heat energy other than that produced by the body itself. If a man is forced down in cold climates, he continues to have adequate protection. On the other hand the excessive weight of such clothing, when worn on the ground before flight, is apt to cause perspiration, which may increase the sensation of cold at high altitudes. Because of its bulk, movement is restricted and flying efficiency is lowered.

The other type of clothing is electrically heated. This clothing consists of a light leather or cloth coverall, with electrical heating elements in the lining. For heat production, this clothing requires an external source of energy, which comes from the electrical system of the aircraft. It is light and therefore does not restrict movement in the air or cause preflight overheating. The fault of this type of clothing

Figure 2-12.—Subjects receiving instruction in the handling of oxygen equipment during a chill run in a low pressure chamber. Navy standard aviator's cold weather shearling clothing is being worn.

lies in the possibility that power failure will eliminate the source of energy for heating it. Too, should the aircraft be forced down in a cold climate, the individual would be inadequately protected for survival.

Cold has certain physiological and psychological effects upon the individual. The drop in environmental temperature brings about an increase in metabolism, muscular tone, and muscular activity in the form of shivering. The early chilly sensations, as the exposure to cold becomes more severe, change to a definite sensation of discomfort as the compensating mechanisms prove inadequate. This sense of discomfort results in a decrease in touch sensitivity, in muscular reaction, and in coordination.

The muscles assume a state of tonic contraction, which hampers the free movement of the extremities. Peripheral circulation decreases in the extremities because of vasospasm, and with severe vascular changes one may encounter tissue anoxia, resulting in tissue destruction. The lower temperature increases the oxygen consumption. This factor, together with the diminished oxygen supply, increases the tendency for tissue destruction. Anoxic failure may result from the establishment of a vicious cycle wherein the body reaches higher and higher altitudes and demands more and more oxygen, and at the same time enters an environment which has a diminishing partial pressure of oxygen.

A flier's emotional state is also affected by cold. Muscular incoordination, which limits his ability to control his aircraft properly and the psychological reaction to physical discomfort, result in a loss of morale. With the deterioration of physiological responses of the body, panic, indifference, and finally stupor may result.

Frostbite.—Actual destruction of tissues, as seen in cases of frostbite, have in the past been common among aviation personnel. It is necessary to keep the extremities warm and protected from the cold wind blasts to avoid ischemia, that results from vasospasm. Indoctrination to the hazards of low temperature and frostbite, together with first aid procedures, is necessary for all flying personnel.

The environmental temperature, especially that at high altitudes, must be taken into account in the use of oxygen equipment. Caution must be exercised and constant checking carried out to avoid freezing of equipment, particularly since expired breath is always vapor-charged.

The problem of extremely high temperatures has so far been fairly well controlled only at the lower altitudes. In a cockpit the pilot is quite well protected from external ambient temperature, but with a large canopy he becomes subjected to increased radiant heat. Where suitable cooling methods were not available, cockpit temperatures as high as 150 degrees F. have been reported, which resulted in the blistering of the pilot's hands when attempts were made to operate the controls. Cooling systems involving the rapid expansion of compressed air have been installed to control this rise in temperature due to radiant heat. These systems have their drawbacks, especially in regions where high humidity prevails. Here the expanding air may condense the vaporized water and deliver it to the cockpit as a small snowstorm, with a consequent reduction in visibility.

The protective element of the atmosphere in absorbing radiant energy decreases markedly as greater altitudes are reached. In a closed cockpit this may result in considerable increase of heat in the plane. Skin friction produced by the higher speeds reached by present day aircraft is another source of heat. Aircraft engineers estimate that the skin friction temperatures generated by newer aircraft will be in excess of the melting point of all known plastics. Temporarily, this will necessitate a return to glass for canopies and windshields, constituting a step backward in the matter of pilot safety in the case of an accident. The present temperature problem is, as discussed in this chapter, a twofold one; protection from ambient cold at high altitudes and protection from radiant and frictional heat.

NOXIOUS GASES IN AVIATION

The noxious gases that are exhausted from an operating internal combustion engine create an important problem in aviation medicine. The most important and deadly constituent of engine exhaust gases is carbon monoxide. Other gases and particles in exhaust vapors are present in such small quantities and are so much less toxic than carbon monoxide, that they are of little practical importance. Exhaust gases contain carbon monoxide, carbon dioxide, methane, butylene, nitrogen, oxygen, hydrogen, water, and various aldehydes including acrolein, methyl, ethyl aldehydes, and paraformaldehyde.

Carbon monoxide varies from 1 percent to 7 percent in exhaust gases, with an average of 3 percent. The amount varies with the octane rating of the fuel, the fuel air ratio, the throttle setting, and the altitude.

Since, as stated above, carbon monoxide is the most deadly constituent of exhaust gases, the major portion of this discussion will be on the physiological effects of this gas. The hazard of carbon monoxide contamination is much greater in the single-engine plane than in the multiengine plane. This is due to location of the engine in the single-engine plane directly in front of the fuselage, where the propeller blast forces the exhaust gases under and about the cockpit. Earlier single-engine planes without exhaust collector rings were completely enveloped in a cocoon of exhaust gases, as demonstrated when a smoke-producing oil was injected into the carburetion system. With the advent of exhaust collector rings the exhaust gases were deflected to the sides and below the fuselage. There is a constant danger of contamination, however, in single-engine planes

should the sealing of the cockpit be unsatisfactory. The cockpit air is generally at a slightly negative pressure to that of the air surrounding the plane. Consequently, exhaust gases will seep into the cockpit and remain there if the cockpit is closed, but incompletely sealed. A major source of cockpit contamination in the past was from exhaust gases seeping through the tail-wheel opening, thence through the fuselage and into the cockpit through cracks around the fire wall in back of the pilot. Proper sealing of the single-engine cockpit eliminates the danger of exhaust contamination.

In the multiengine plane, exhaust contamination remains a danger because of the possible entry through wing passages, ventilating air scoops, and other design features. Exhaust cabin heaters are also a possible source of contamination if leakage occurs. The danger of exhaust contamination is less in pressurized cabins provided the carbon monoxide is not recirculated by the ventilating system.

The toxic action of carbon monoxide is essentially through its effect on the blood, where it produces a deficiency of oxygen in the body. Unlike most poisons, carbon monoxide in lesser concentrations does not have a direct effect on the cells of the body, but in high concentrations it has a toxic effect on the respiratory enzymes of the cells. In the concentration generally encountered the effect is primarily on the red blood cells, actually interfering with the transportation of oxygen from the lungs to the tissues. If elimination is soon enough and the concentration not too great, permanent damage does not result. The hemoglobin molecule takes up carbon monoxide in the same way that it does oxygen, forming carboxyhemoglobin. At body temperature its affinity for carbon monoxide is 210 times greater than oxygen. To make the situation more serious, the presence of carboxyhemoglobin tends to make the remaining hemoglobin bind to its oxygen more tenaciously, so that it does not give it up to the tissues readily.

The variables that determine the quantity of carbon monoxide taken up by the blood are: the concentration of the carbon monoxide, the duration of exposure, and the degree of activity of the individual. Obviously, the first two need no explanation. There is a more rapid absorption of carbon monoxide, with an increased respiratory and circulatory rate, from increased activity.

The initial effects of carbon monoxide poisoning are produced by the developing anoxia. These are insidious and consist primarily of inattention, reduced concentration, slight muscular incoordination, and sleepiness. While these symptoms are not permanently injurious to health, they are dangerous to flying personnel and may result in serious accidents. Headache is the most prominent symptom up to 30 percent concentration, and beyond 30 percent concentration the impairment of behavior is generally quite extreme.

Symptoms:

Percent COHb:

0-10—No subjective symptoms. Visual impairment by objective tests.

10-20—Tightness across forehead, slight headache, dilatation of cutaneous blood vessels.

20-30—Headache with throbbing in temples.

30-40—Severe headache, weakness, dizziness, dimness of vision, nausea and vomiting, collapse.

40-50—Same as preceding, but more severe.

50-60—Loss of consciousness, irregular respiration, rapid pulse, coma, with intermittent convulsions.

60-80—Coma, convulsions, depressed heart action, respiratory failure, and death.

Under normal conditions the time required to reduce the carbon monoxide in the blood is a matter of hours. In a man at rest, the average time for the percent of carboxyhemoglobin to fall one-half its value is 4 hours. Breathing pure oxygen reduces the time from 4 hours to 40 minutes. Combining 5 percent of carbon dioxide with the oxygen produces an even more rapid elimination of carbon monoxide because of its stimulation to respiration.

Rate of carbon monoxide elimination at sea level.

30 to 25 percent	1 hour
25 to 20 percent	1½ hour
20 to 15 percent	2 hours
15 to 10 percent	2½ hours
10 to 5 percent	3-5 hours
30 to 5 percent	10 to 12 hours

Flight crews who suspect the presence of carbon monoxide or any exhaust gases should

breathe 100 percent oxygen by turning off the diluter-demand feature in their oxygen equipment.

The maximum allowable limits of carbon monoxide in aircraft has varied in the Navy from .002 percent to .01 percent, depending upon the wartime exigencies. Most physiologists agree that the maximum should never exceed .0025 percent. Since carbon monoxide does nothing but harm to the body, 0 percent is the ideal maximum.

Other harmful noxious gases present in aviation are:

1. The vapors from oil after contact with heated parts of the engine. These may cause irritation to the eyes and respiratory tract and result in headache, nausea, and vomiting.
2. Hydraulic fluids sprayed from breaks in lines may cause similar symptoms.
3. Gasoline vapors absorbed through the lungs may effect the nervous system in a manner similar to alcohol.
4. The exhaust gases from jet assisted take-off units contain carbon monoxide and a fairly large percentage of hydrochloric acid.

The elimination of noxious gases as a dangerous factor in aviation may be outlined as follows:

1. Aircraft designed so that exhaust gases do not enter the cockpit or cabin.
2. A system of regular inspections for breaks in firewalls, exhaust heaters, gasoline heaters, etc.
3. The training of flight personnel to realize the possibilities of exhaust contamination, and the instruction of flight personnel to put on their oxygen equipment, with the diluter off, immediately upon suspecting such contamination.

PRESSURIZED EQUIPMENT AND EXPLOSIVE DECOMPRESSION

In present-day and future aircraft design the intention is to attain altitudes in excess of 43,000 feet. If human beings are to fly in aircraft at such altitudes, they will need additional protection from decompression. The nature of the protection to be afforded centers around the application of increased air pressure in the immediate environment of the human being. Devices for such protection are pressurization of the cabin or cockpit in which the individual flies or a pressurized suit.

By the use of such devices, it is possible to maintain pressures higher than the ambient atmospheric pressures found above 43,000 feet. If the cabin, cockpit, or suit is pressurized to the extent that the environmental pressure about the human being is equal to an altitude of less than 10,000 feet, extra oxygen is not necessary. If the pressures are less than that corresponding to an altitude of 10,000 feet and range from 10,000 to 43,000 feet, then extra oxygen must be supplied and precautions taken against the occurrence of decompression illness.

In the construction of an aircraft the installation of a positive pressure cabin or cockpit entails added weight to the aircraft and numerous technical difficulties in design and construction. This added weight may modify the performance of aircraft both in its duration of flight and performance during flight. The seal for the cabin or cockpit must be such that the pressurizing equipment will be able to maintain given pressure and ventilate such spaces at a proper rate. There is always the danger of a large leak, produced by damage to the seal of the compartment, which makes it impossible for the pressure to be maintained. A sudden loss of pressure results in a change of barometric pressure to the individual which is spoken of as *explosive decompression.* Such a rapid decompression may result in serious symptoms if it covers a fairly wide range of pressure.

The dangers of explosive decompression involve the areas of the body in which there are large quantities of air. These areas are the intestinal tract, the lungs, the sinuses, and the middle ear cavity. Since the middle ear and the sinus cavities have free access to open air, little if any injury would result in these areas. If the glottis is open and the individual is breathing in the expiratory phase of respiration, the expanding lung air as a result of sudden decompression would vent itself easily to the outside. However, in the inspiratory phase of respiration, or with the glottis closed, serious damage might result to the parenchyma of the lung by the sudden expansion of the intrapulmonary air. The sudden expansion of intestinal gas might be painful and produce

a shock-like reaction if the individual was unable to permit the escape of the expanding gas. There might also be a sudden thrust against the diaphragm, pushing it upward (simulating a sudden violent expiratory effort).

Since the expansion of the air in the lungs would simulate a sudden violent inspiratory effort, these two conflicting events would bring about apnea. If one is suffering from lack of oxygen during such an explosive decompression, the superimposed apnea would increase the anoxia. Actually the hazards of explosive decompression are not great, and in experiments with human beings as well as with animals, explosive decompression from sea level or a low altitude to a pressure altitude of 50,000 and 60.-000 feet has been well tolerated as long as 100 percent oxygen under pressure is furnished to the individual.

If aviators are to be safeguarded against anoxia as a result of explosive decompression, aircraft should have available for the use of occupants pressure-breathing oxygen equipment or pressure suits in the event of such decompression. Such devices would safeguard the individual and bring about a greater chance of survival at altitudes in excess of 43,000 feet, should cabin or cockpit pressure be lost.

To maintain the pressure in pressurized cabins, and at the same time to provide fresh air for ventilation, the usual procedure is to pump air into the cabin continuously and allow the excess to escape through a valve. This valve is set to open only when the internal pressure—or when the difference between internal and external pressure — reaches a predetermined level. The amount of air pumped per minute then depends on the requirements for ventilation.

In a closed space, such as exists under these circumstances, it is important that the conditioning of the air be adequate for physiological efficiency. If a system such as that described above, (in which air is continually pumped in and allowed to escape), is used the volume of air needed per minute depends mainly on the quantity required for maintaining proper humidity. This requirement is greatly in excess of the ventilation needed to compensate for the rate at which oxygen is used up, or to wash out carbon dioxide, cabin and body odors, and so forth. The inlets for air to the pumps must be carefully placed to avoid contamination with carbon monoxide from engine exhaust gas.

QUESTIONS

The following review questions on *problems of reduced barometric pressures* should be helpful:

1. What are the physical characteristics of the atmosphere that limit flying to relatively low altitudes?
2. Explain Boyle's Law. Dalton's Law.
3. Outline the symptomatology encountered in the relative stages of anoxia at 10,000, 15,000, 25,000 feet.
4. What are the limits of positive pressure measured in inches of water which may be applied to the lungs of the average young adult and how much added ceiling will this pressure give him?
5. Explain the problem of free gas expansion in the body at altitude.
6. How may disability due to free gas expansion be avoided?
7. Above what altitude is aeroembolism a major physiological factor?
8. Explain preoxygenation for aeroembolism prophylaxis.
9. Explain the principle of the diluter-demand oxygen regulator.
10. Why does anoxia become progressive even when 100 percent oxygen is used above 34,000 feet?
11. What is the temperature in the stratosphere and above? What is the rate of progressive decrease in temperature ascending above sea level?
12. What are the two types of cold weather clothing used in naval aviation?
13. Explain why carbon monoxide is a danger in aviation?
14. What is the desired maximum allowable limit in carbon monoxide concentration in aircraft?
15. Describe a pressure cabin.
16. What is the major danger to personnel in explosive decompression to 50,000 feet?

BIBLIOGRAPHY

1. *Principles and Practice of Aviation Medicine.* Armstrong.
2. *Human Factors in Air Transport Design.* McFarland.
3. *Anoxia; Its Effect on the Body.* VanLiere.
4. *Compendium of Aviation Medicine.* Ruff and Strughold.
5. Naval aircraft oxygen equipment handbooks and publications.

CHAPTER 3

THE PROBLEM OF ACCELERATION *

The term *acceleration* as applied to aviation medicine requires the consideration of several factors, including the kind of acceleration, its magnitude, duration, and direction. The kinds of acceleration are linear, radial, and angular. Linear accelerations of greatest concern to aviation medicine are of very short duration and high magnitude, as evidenced in aircraft crashes.

Radial accelerations are encountered in the turning and maneuvering of aircraft or in the tumbling of ejection seats or capsules upon release from the aircraft. Radial accelerations are of lesser magnitude generally, of longer duration, and are of interest principally because of the effect of the resultant forces on the fluid elements of the body. In this connection, the position of the pilot's body is very important and the terms positive, negative, and transverse are used respectively to designate whether the force is acting from head to foot, from foot to head, or at right angles to the long axis of the body.

Angular accelerations are of low degree and long duration and involve rotation about the long axis of the body, with resultant stimulation of the vestibular system; thus, they may confuse and disorient the pilot.

To understand the physiological effects of acceleration, and thereby the accelerative stresses developed in aviation, a brief review of the physics of acceleration is of value.

Velocity $(V) = \frac{\text{ft.}}{\text{sec.}}$. As long as V is uniform no apparent changes are developed within the body. This is best demonstrated by the fact that as a part of the earth we, as individuals, travel through space around the sun at about 18 miles per second. In so doing we experience no particular sensations referable to such travel. Acceleration, by definition, is a change in velocity. Since velocity, however, is a vector quantity, this change may be one either of magnitude, or speed, or direction. For a body in constant motion, acceleration either in speed or direction requires the application of a force to the body. In its simplest form this force may be defined as $F = mx \propto$, where $F =$ force in pounds, $m =$ mass of the object in pounds and $\propto =$ the acceleration imparted to the object in feet per second per second.

When the earth's gravity force is the force used, the mass and weight of objects are numerically equal; for $F = \frac{W}{g}$ where $\frac{W}{g} =$ weight at 1 g or under a force equal to the pull of gravity. If a force produces an acceleration twice that of gravity or 2 G, this becomes $F = \frac{W}{g} \text{ x } 2g$. Thus $F = 2W$ or the force effectively doubles the weight of the object. More specifically, the force doubles the effective weight of the object. This relationship is the basis for the chosen unit of acceleration force, which is 1 g or the force of gravity. If a known acceleration is divided by 32.2 ft/sec^2, the acceleration of gravity, $F = mg$ where g is the force in terms of gravity. Although it is of a constant mass, the object will have an effective weight proportional to the g, i.e. $10W$ for 10 g.

Changes of velocity in regard to speed are defined as linear accelerations and may be either increases or decreases. Common examples of this type of acceleration seen in aviation are take-off, landing (both accentuated on aircraft carriers by catapults and arresting cables), the opening of a parachute, the contact of a parachuter with the ground, crashes,

* Prepared by F. R. Stauffer, LT (MC), USN

and, more recently with high speed planes, mid-air engine failure.

The type of physiological change incident to such an acceleration is common to almost everyone. In low magnitude they are reproduced by stops and starts in elevators or jumps from small heights. In greater magnitude they are met in impacts following falls from greater heights and the common tragedy of automobile collisions. If it is appreciated that all body tissues and structures are held together by varying cohesive and adhesive forces, the effects of such accelerations may be easily understood. As long as the force producing the acceleration is applied uniformly to all parts of the body, no detrimental action occurs.

This is best seen in an aviator's free fall following bail-out from an airplane and prior to his parachute's opening. Here, under the force of gravity producing an acceleration of 32 feet per second per second, he experiences no changes referable to such acceleration. When, however, an accelerating force is applied unevenly, certain stresses are immediately imparted to the body. These, if great enough, may exceed the normal intertissue tensions and result in the lacerations, contusions, torn muscles and ligaments, and even fractures which so frequently are seen in falls and collisions. The unevenness of application may be shown by the example of a simple fall. That part of the body striking the ground first will begin to decelerate while the rest of the body continues to fall. This results in extensive compression of the tissues striking first.

To cite another case, restraining shoulder straps, during a crash, will decelerate a pilot's thorax, with some chest compression, while the undecelerated head continues forward. This will strain the ligaments and vertebrae in the cervical area. The same pilot, also, if his head strikes some irregular structure within the cockpit, will experience localized deceleration of the head, with a possible compression fracture or even a penetrating wound of the skull.

Since the normal tissue tensions are fairly high, fairly high accelerative or decelerative (slowing) forces are necessary to effect body changes. The time necessary for these forces to act to accomplish their results is, however, short, because the body changes, once produced, tend to be permanent until medical repair is instituted. These crash injuries are, therefore, most commonly associated with high forces, 40 g or more, acting for a short time (small fractions of a second).

Protection against this kind of g force may be obtained in several ways. It has been calculated that $g = \frac{V_1^2 - V_2^2}{32.2 \times 2d}$ where V_1, and V_2 are the initial and final velocities and d is the distance covered during the acceleration. In crashes, for example, where $V_2 = O$, this reduces to $G = \frac{V^2}{32.2 \times 2d}$ Consequently, if d can be increased, a given V will produce less g. An airplane making a belly landing on a flat field, for example, will produce less g than one crashing into the side of a building. More immediate in pilot protection are shoulder straps and seat belts. With some give these may allow the pilot himself to decelerate within the cockpit.

Since d is inversely proportional to g, doubling d will halve the g force. Thus, shoulder straps decelerating the pilot more than 2″ will allow him to take twice as much g force as would straps decelerating him in 1″. Similarly, people falling into shrubbery or soft compressible dirt, by decelerating over a greater distance, can survive, uninjured, falls from greater heights than people landing on concrete, where d is practically zero. d may also be expressed as t or time of deceleration. The greater the distance, the greater the time.

Protection may also be provided by altering the force distribution on the body. In crashes this is especially true. Since the g force is constant for a given velocity, it follows that the effective weight will also be constant. If the weight of the object can be supported over a greater area, the force per unit surface will be decreased. Thus a single force applied as pounds/sq. in. may be distributed over 50 sq. ins. as 1 pound/sq. in. More specifically, shoulder straps restraining a body with possible fracturing of the clavicles can be replaced by a vest, where the impact is distributed throughout all the ribs with a resultant greater total force tolerance. In this respect forces up to 100 g have been sustained without serious injury during falls where the individual

landed flat on his back and thus distributed the force simultaneously over a large area of his body.

Finally, protection may be obtained by dissipation of the force outside of the body. This may be done by the absorption of force during the collapse of structures in the airplane anterior to the pilot, such as the propeller, engine, and the forepart of the cockpit. More directly, protection may be afforded by the inclusion of energy-absorbing materials in such wearing gear as crash-helmets. Crash helmets, in addition, distribute the force from local areas to a greater portion of the head surface. Within the body, even, force may be absorbed by the compression of soft tissues or the bending of joints, with less damage than is sustained by those less energy-absorbing structures such as rigid bones.

Thus it may be seen that the problems of linear acceleration in aviation are but an extension of similar problems in civilian life. Of a more divergent nature are the problems of acceleration involving a change of direction, with or without changes of speed. For convenience these changes of direction have been termed radial accelerations, because the centripetal force causing the acceleration may be measured fairly easily by its counterpart, centrifugal force. Here $F = \frac{mV^2}{R}$ where $\frac{V^2}{R}$ equals the radial acceleration and R is the radius of the circle involved in the curved path.

Such forces may be experienced in aviation during normal banking turns, in pulling out of dives, and in various aerobatic maneuvers such as spins and loops. As in linear acceleration, the force in terms of g can be calculated for a constant mass by merely dividing the acceleration of gravity or $g = \frac{V^2}{32.2\,R}$. Although in aviation V is usually hundreds of miles per hour and R is usually in thousands of feet, a reduction of both of these would give comparable g forces.

Such a reduction has been produced on a practical scale in the construction of Human Centrifuges. These machines, capable of up to 100 r.p.m. and with radii of 20 feet, are thus able to simulate the radial acceleration forces found under most conditions of aircraft maneuvering. By accurate control of V and R, therefore, animals and humans may be intensely studied under laboratory conditions to determine the physiological effects of such forces and the safe limits to which the body may be so stressed. One such machine is at the School of Aviation Medicine and Research, Naval Air Station, Pensacola, Florida. (figure 3-1.)

This type of force tends, at present, to have much lower g forces than the common injurious linear accelerations. Thus, the tearing of tissues and the fracturing of bones, common in crashes, are rarely encountered. The low forces of radial acceleration are, however, sustained for considerable lengths of time, often several seconds. Such a sustained force can result, eventually, in overcoming the inertia which tends to prevent certain nonfixed tissues and organs from altering their normal body relationships.

Of primary importance in this respect are the body fluids, blood, lymph, and cerebrospinal fluid. These fluids are normally contained in tubular structures which are seldom filled to capacity. The walls of the tubes, furthermore, are elastic and porous and so may stretch and leak. Physiological balance is normally maintained by an equilibrium of intra—and extravascular forces, a predominant factor of which is intravascular hydrostatic pressure. Within the blood vessels the internal hydrostatic pressure at any point is made up of two factors, residual pressure from the heartbeat and hydrostatic pressure resulting from the weight of the column of fluid above the point. It is this last which is most altered by radial acceleration. Since effective weight is altered proportionally to g, this portion of the intravascular hydrostatic pressure at any point will vary as the multiple of the weight of the fluid column above it. For example, at 13 g the effective weight of blood or any water fluid will approximate that of mercury at 1 g.

Perhaps the simplest consideration of the physiological effects on the fluid systems may be seen in the results following a change from the horizontal to the erect position. The immediate result of such a postural change is a pooling of blood in the dependent areas as the vessels there expand to hold more fluid. This pooling occurs on the venous side even

more than on the arterial side and results, consequently, in a decreased venous return to the heart.

The cardiac output, therefore, falls and with it the arterial pressure in such sensitive areas as the carotid sinus and aortic arch. Reflexes are then initiated resulting in widespread vasoconstriction in areas below the heart. This tends to decrease the pooling tendencies and thus insures a more adequate return of blood to the heart. This is accomplished not so much by increasing the rate of flow through the lower areas but by decreasing the amount of blood that can descend and the average distance it can descend. Thus, less work is required to raise it back to heart level. Venous return is normally augmented by skeletal muscles acting as pumps on the venous system. In a quiet, erect individual the lack of the muscular pumps gradually allows pooling to occur in spite of any widespread vasoconstriction, so that blood pressure eventually falls and syncope, from cerebral anoxia, may occur. But in the average individual, under average conditions, the vasoconstriction and muscular activity supply the heart with a sufficient return of blood so that it can then pump an adequate supply against gravity ($1g$) the short distance upward to the head. This last follows, obviously, from the fact that in man the erect position is so well tolerated.

Under radial acceleration, then, these changes are merely intensified. The greater effective weight of the blood produces a greater tendency to pool and a greater obstruction to

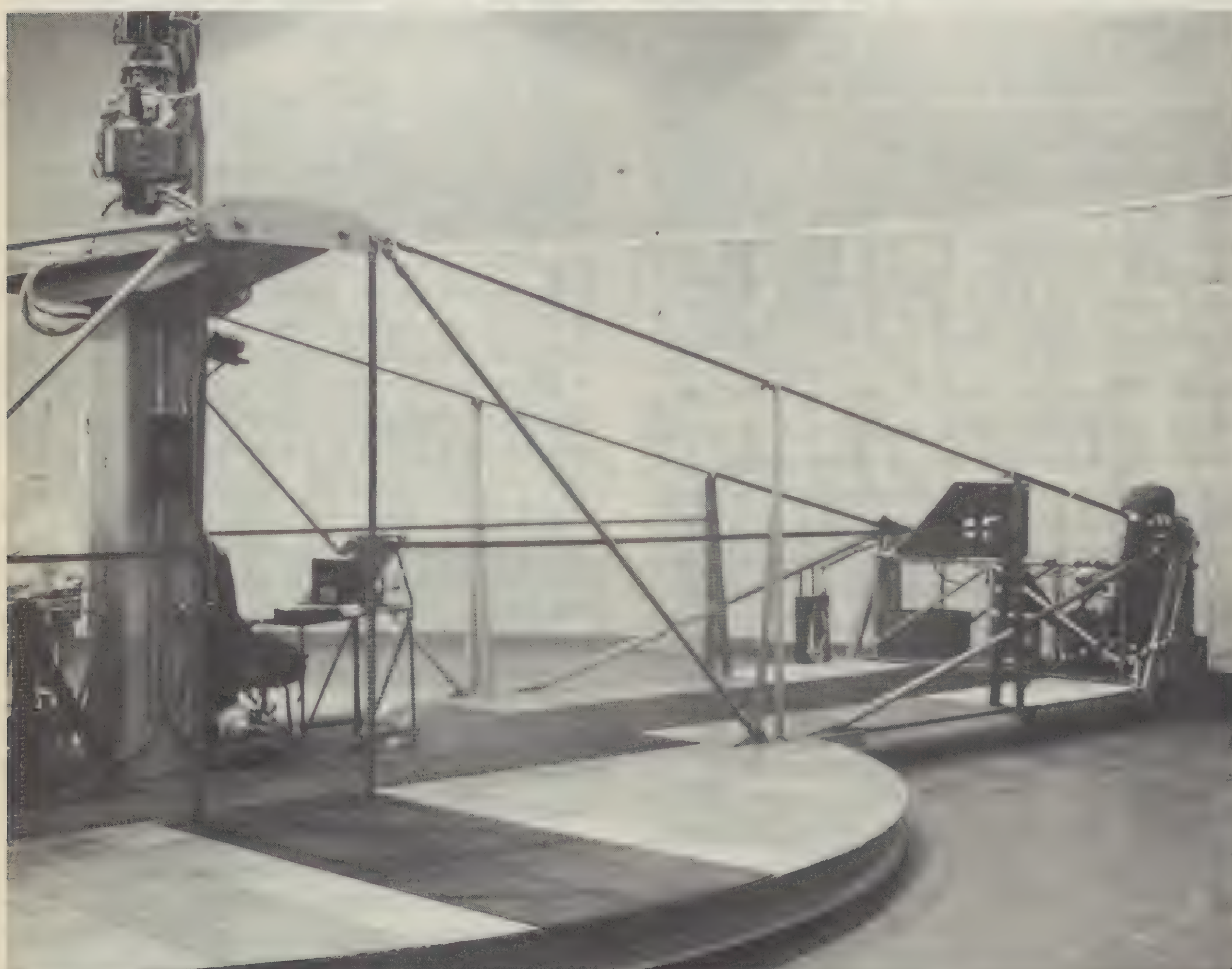


Figure 3-1.—Human Centrifuge at the School of Aviation Medicine and Research, Pensacola, Florida, showing center column, revolving platform with observer's seat at the center and subject's seat at the end of the centrifuge arm.

venous return. In addition, raising the heavier blood to the head becomes a greater load on the heart even when adequate blood is present. It follows, then, that if the radial g is raised sufficiently high the reflexes involved will become inadequate. Pressure studies on the centrifuge have offered conclusive proof of this. Blood vessels below the heart, away from the center during centrifugation, have shown a linear increase in pressure directly proportional to g. Conversely, vessels above the heart have shown linear decreases in pressure directly proportional to g. Eventually, such a decreasing pressure in the head must reach a subfunctional level.

Vision is the first sense to be distributed or to fail. Since the intraocular pressure is normally about 28 mm. Hg, it is therefore to be expected that when the cranial blood pressure has fallen to this level the vessels supplying the retinae would be collapsed. Moreover, those vessels extending to the periphery of the retinae would be subject to intraocular pressure over a greater length and thus collapse more readily. Peripheral vision, therefore, should and does fail first. On the centrifuge (figure 3-2) the subject has three lights to observe, a central one and two in the peripheral visual field. These lights are easily turned out by buttons under the right and left hand. If the lights are turned on at random intervals and if the subject is instructed to turn them off when seen, it is apparent that a g-level can be reached where he leaves the peripheral

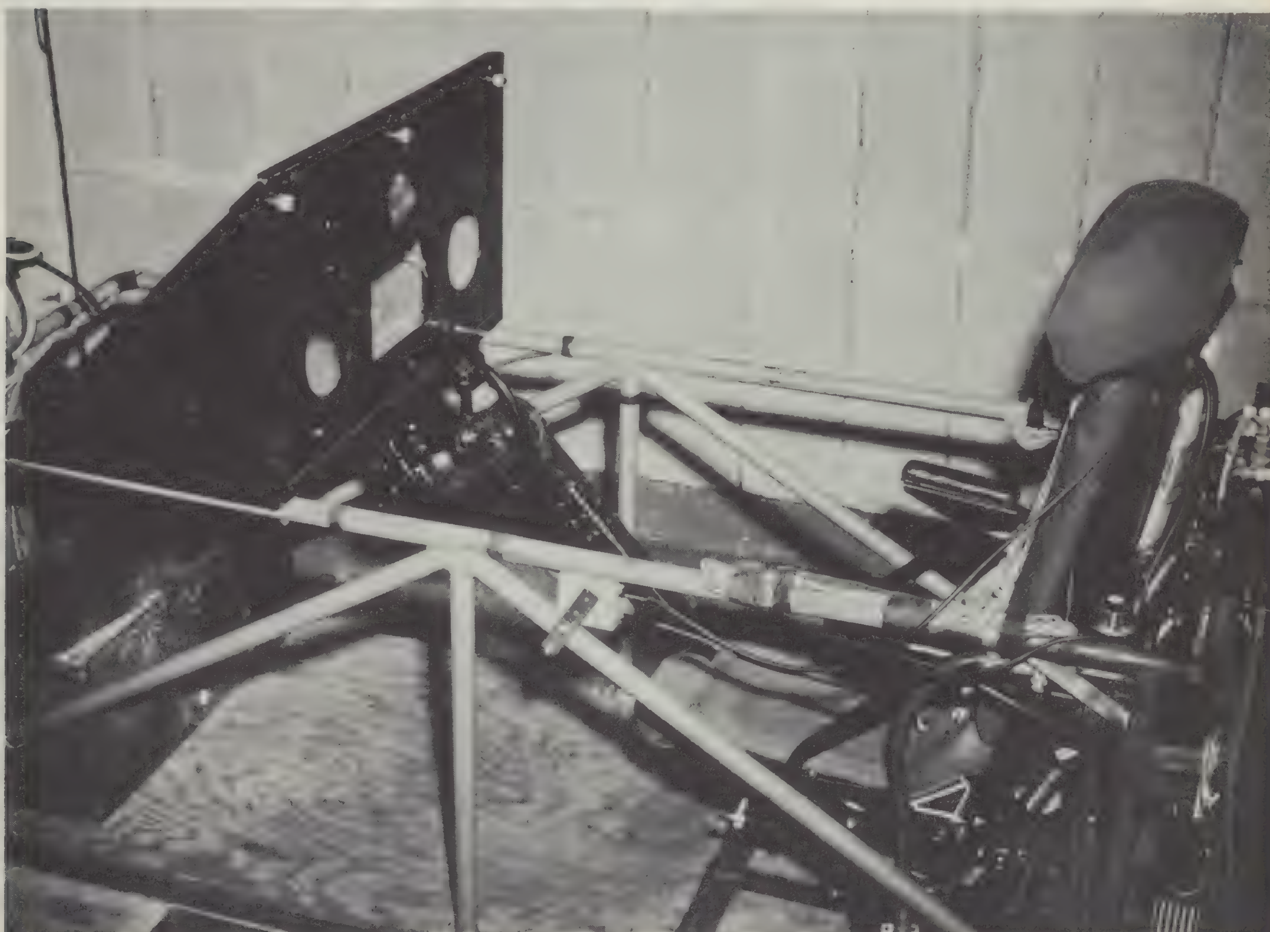


Figure 3-2.—Close up of subject's seat on the Human Centrifuge. Note: (1) the conventional wheel-type of control with buttons at thumb level to turn out control panel lights; (2) control panel with 3 lights at eye level above the accelerometer; (3) Standard G-valve for suit pressure on railing at extreme left rear of subjct; (4) absence of foot pedals to eliminate tensing and bracing of legs; (5) miscellaneous wiring for the lead off of ECG, respiration (via thermocouple in the mouth), ear opacity and ear pulse (via photo-cell unit), suit pressures and acceleration.

lights on and still turns out the center lights. He is in a condition, then, of peripheral lights lost or *PLL*. At a slightly higher *g*-level the central retinal arteries will collapse also and the subject will leave all of the lights on. His condition then is one of center light lost (*CLL*), or black-out (*BO*). At this point he still has an effective supply of blood to the rest of the brain, enhanced by a negative intracranial cavity spinal fluid pressure.

It must be remembered that spinal fluid is also subjected to a dependent pooling force. But the rigid character of the cranial cavity prevents the general collapse of all intracranial vessels and spaces, so that fluid is maintained in these areas at pressures below atmospheric. This has been well demonstrated by movies of cranial vessels seen through watertight leucite windows in the skulls of monkeys subjected to such centrifuge studies.

At black-out level the ringing of a bell, which the subject turns off in a manner similar to the lights, serves as further evidence that the subject's only failing is one of sight, that he still has adequate circulation for hearing, motor control, and consciousness in general. Higher *g*-levels still will, obviously, eliminate even this last bit of circulation to the head. Unconsciousness then ensues. The bell is left ringing, the hands drop from the wheel, and the head slumps forward on the chest.

Ordinarily, experimental centrifuge runs on humans last from 10 to 15 seconds. This time interval is quite sufficient to establish the end-points desired, yet insufficient to cause permanent cerebral damage from temporary anoxia. Subjects who have had thousands of such centrifuge runs over a period of five years have spent "hours" blacked-out and "minutes" unconscious. They show no clinical evidence of any changes attributable to these experimental procedures.

Since the essential stresses involved are of a nature of decreased venous return from the areas below the heart and of a decreased supply of blood to areas above the heart, it is understandable that the duration of the *g* stress is important. Compensation for a low *g* force might and does fail when the force is sustained, while a higher *g* force may be well tolerated for a shorter time. Many people will faint on a tilt table when held quietly erect for twenty minutes. On the other hand, snap acrobatic maneuvers producing *8* to *10 g* are well tolerated as the *g* is sustained for a second or less. The range for black-out threshold in average adult males during 15-second centrifuge runs is *2.5* to *7.5 g*, with the mean between *4.0* to *4.5 g*.

One might ask how frequently are these levels approached in aircraft. Planes have recently crossed the continent averaging 600 m.p.h. At this speed a turn with a radius of 2 miles would impose a centrifugal force of 9.5 *g* on the aircraft and all its occupants. Even a turn with 5-mile radius will produce 3.5 *g*. Now this level frequently produces visual dimming or PLL if maintained for approximately 10 seconds. At 600 mph 15 seconds would be necessary to complete a 180° turn at this speed!

Still other physiological changes of a circulatory nature may occur under radial acceleration. In the capillaries, for instance, the intra-extravascular fluid balance is maintained by four primary factors. Intravascular hydrostatic pressure (HP_v) and the collodial osmotic pressure of the tissues (COP_t) act to move fluid outward. They are opposed by the hydrostatic pressure of the tissue spaces (HP_t) and the colloidal osmotic pressure of the blood, largely from plasma proteins (COP_v). Normally HP ranges from 35 mm. Hg. in the arterial end of the capillary to 15 mm. Hg. in the venous end. COP_v remains fairly constant at about 25 mm. Hg. Under *g*, however, this balance is greatly upset by the transmission of increased hydrostatic pressure from both arteries and veins to the capillary bed.

The result is a greatly increased outward filtration of fluid and a consequent concentration of the blood. By increasing the blood's viscosity this concentration further impairs the venous return. Systemic (arterial) plasma protein concentrations have shown increases of 5 to 10 percent in young goats after only 30 seconds of 5 *g* stresses. Such increased filtration is also accompanied by extensive extravasations of plasma protein, which not only makes the 5 to 10 percent concentrations increases more significant but also decreases the ease of returning the fluid to the blood when

Figure 3-3.—The Standard U. S. Navy Z-2 anti-blackout suit partly inflated (note abdomen). Note also the air source is attached by means of a quick disconnect on the left. Also pictured is a standard G-valve and oil filter to demonstrate, statically, the method by which the suit fills under simulated G. This suit can be worn in place of the conventional coverall and is light weight and porous for skin ventilation. It may be worn under cold weather gear without discomfort or impairment.

the stress is terminated. Consequently, edema is a common finding in those body areas where tissue pressure cannot rise to counteract the filtration tendencies. This is characteristic of skin and mucous membranes, and more so of subcutaneous areas. In muscles, on the other hand, and similar tissues with inelastic and watertight membranes, a small extravasation of fluid produces a marked rise in tissue pressure, thereby restoring the vascular balance. This protects the involved vessels against further fluid loss or greater dilatation.

The usual return of filtered fluid to the blood, especially when high in protein, is via the lymphatic system. These vessels, however, are subject to the same *g* forces, and flow in them is prevented by the same increase in hydrostatic pressure as occurs in the arteries and veins. In particularly poorly protected blood vessels, or under higher *g* forces, the intravascular pressures may rise so much that they not only increase filtration and the loss of plasma protein, but they may even cause extravasation of formed blood elements, petechiae, and finally frank hemorrhage. Petechiae, for example, are frequently observed in humans after only 10 seconds at 6, 7 or 8 *g*.

In addition to fluid readjustments under radial acceleration, both of a translocation within the vascular tree and a rebalance between intra—and extravascular areas, other pertinent changes may be noted. These involve primarily an increase in the effective weight of some areas beyond the limits of the skeletal muscles involved to move them. Below blackout threshold there appears to be little impairment of hand, finger, and foot movement as regards operating controls efficiently. There is, however, a definite sensation of being pushed into the seat. At about 3 to 4 *g* raising the arms above the head and, more importantly, standing up from the seat (e.g., to escape from an uncontrolled aircraft), become quite difficult if not impossible. Finally, a few incidences of ruptured intervertebral discs have been reported following severe pull-outs from dives in aircraft. The *g*-level in these cases, however, was undetermined.

The means of protecting an individual against this type of force is therefore important. Several have been devised. The original clues toward the solution of this problem were obtained from pilots who learned, by trial and error, ways to diminish their black-outs. More recently centrifuge tests have demonstrated various factors affecting one's black-out threshold. Tensing of muscles, especially of the abdomen seemed to help the most; but it was also found that a full stomach, apprehension, and good physical condition also increased one's *g* tolerance. The common denominator of these protections is fairly apparent. They aid the leg and abdominal blood vessels by either actual external pressure or by increasing vasoconstriction and blood pressure. They, therefore, act to prevent the dilatation of the vessels, pooling, and filtration. In addition, the increased pressure aids in supplying blood to the head.

Such an understanding has led to the development of the present standard antiblackout suit. This suit is simply a tight-fitting garment with five air bladders (one over each calf, one over each thigh, and one over the abdomen) incorporated in the cloth over those soft tissue areas most prone to allow pooling. The bladders are attached by means of a *g*-valve to operate automatically and fill with increasing pressure for increasing *g*. The principal of the valve is simply an application of Hooke's Law that a spring will be stretched proportionately to the weight applied. Since the effect of *g* is to increase the weight, a plunger can be so attached to a spring that under 1 *g* it covers the air pressure inlet. Under increasing *g* the plunger then progressively uncovers more of the pressure inlet. As *g*-force is removed, the inflow of air is again blocked and properly placed outlet valves can provide almost immediate release of the air pressure within the bladders.

The standard valves in use are adjusted to activate at 1.75 *g*. Above this level they deliver either 1 or 1.5 p.s.i. per *g* depending on whether the valve is set on *low* or *high*. The average protection so afforded is approximately 0.7-1.0*G* for *low* and 1.0-1.5*G* for *high*. Not only does such a suit act to raise the pilot's black-out level; but by its massaging action at sub-blackout levels it benefits venous and lymphatic return and acts, thereby, as a significant antifatigue suit.

As the importance of the height of the hydro-

Figure 3-4.—The Standard U. S. Navy Z-3 anti-blackout suit. This is a cut down model of the Z-2 suit. It may be worn over the underwear and under or over conventional uniforms. It incorporates the air bladder systems of the Z-2 in a form which can be worn with many other clothing arrangements. As pictured it is partly inflated.

static column was realized, another approach to the black-out problem developed. Venous return could be aided by decreasing the vertical distance between the heart and the stressed area. Practically, this may be accomplished by raising the feet and knees, crouching or tilting the seat backward. Crouching also was beneficial in decreasing the heart to head distance although vision was then impaired. The limiting changes in this regard are, naturally, based on the assumption of a prone or supine position. These positions, while good hydrostatically, offer considerable difficulty in the operation of controls, introduce a problem of vision, and greatly increase the dangers during crashes.

The problem of escape from uncontrolled and spinning aircraft is increased in high speed planes by acceleratory forces. As skeletal muscle capacity is surpassed, automatic escape mechanisms must be employed. The attack on this problem is of two forms. For intermediate velocity aircraft, ejection seats seem promising. In this manner seat and pilot under transient forces of 15 to 20 linear g can be thrown clear of the aircraft. After reaching terminal velocity the pilot may then free himself from the seat or, with an appropriate parachute, ride the seat to the ground.

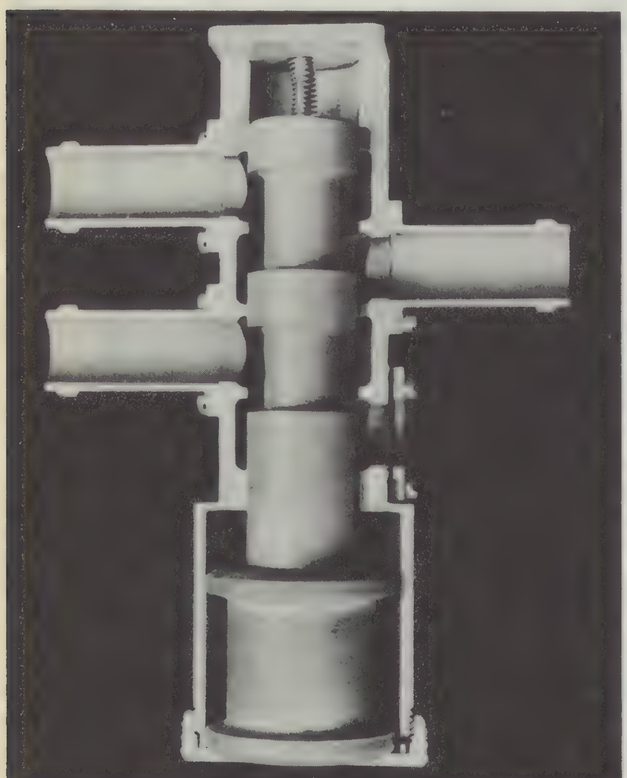


Figure 3-5.—The Standard G-valve, at 1 G. Under this condition pressure from the left normally escapes through an exhaust at the lower right. As G lowers the central column on the spring, part of the pressure escapes via the upper right tube to the suit. After G is removed, this suit pressure then escapes via the small opening at the upper left which was closed during G.

For higher speed planes, wind blast, and tumbling (see below) seat ejection becomes unsatisfactory. Here a segment of the plane, a pod, or capsule containing pilot and seat must first be disengaged from the rest of the aircraft. The final solution has by no means been reached.

Since radial g acts predominantly by pooling blood away from the center of curvature, it is evident that the gross position of the body can significantly alter the physiological effects produced. Radial g has, therefore, been subdivided into various types depending on which area of the body is subjected to pooling. The position so far discussed wherein pooling is toward the abdomen and legs produces what has been termed positive radial g $(+g)$. By the opposite criterion, positions which result in the pooling of blood toward the head end of the animal or man impose a force of negative radial $g(—g)$. There may also be transverse g, either prone with pooling anteriorly or supine with pooling toward the back. Finally there is lateral g with pooling from right to left or vice versa.

From a circulatory standpoint the mechanics in each case are similar to those of $+g$. Because of the anatomical symmetry of the body, however, vastly different physiological disruptions may occur. The blood vessels stressed in negative g, for example, are normally subjected to little stress in an erect position. They are, therefore, less protected and more apt to suffer extensive filtration and hemorrhage. Thus it is that 30 seconds of $—3g$ can produce extensive edema in the soft tissues of the face, head, and neck of goats, profuse hemorrhages submucosally in the larynx, mouth, nose, and sinuses and subconjunctivally in the eye. The larynx under $—5g$ for 30 seconds can become

so edematous and hemorrhagic that the airway is occluded and asphyxiation results.

Intracranially, however, the cerebrospinal fluid protecting the blood vessels experiences the same hydrostatic pressure increases as do the blood vessels. Here, then, very little, if any, disruption of fluid balance occurs. Occassional hemorrhages which have been found within the cranium under negative *g* have been localized largely in the circle of Willis. They are attributed more to a tearing of the vessels which are stretched longitudinally, than to an increase of the intravascular pressure beyond the limits of the vessels. The stretch is a result of the brain's gravitation toward the upper part of the cranial cavity through the less dense cerebro-spinal fluid.

As would be expected under negative *g*, the pressor reflexes are reversed. The increased pressures in areas such as the carotid sinus reflexly slow the heart, further aggravating the poor cerebral circulation. Humans at —3*g* for 10 to 15 seconds have shown by *ecg* a bradycardia of 4 to 6 beats per minute. Rabbits and goats at —5*g* have shown temporary cardiac arrest during 30-second centrifuge runs. Respiration is also markedly impaired under negative *g*. The increased effective weight of the abdomen is thrown onto the diaphragm making adequate inspiration that much more difficult.

While in +*g* it seems possible to pool all the blood below the heart, under —*g* it appears that the cephalad loop of circulation cannot hold the entire blood volume. This results in a residual venous column of blood acting on the right heart. Enough pressure may be thus produced to precipitate cardiac failure in experimental animals subjected to prolonged —*g*. This cardiac threat is also present under +*g* when anti-blackout protection is sufficient to prevent the pooling of all the blood below the heart. Consequently, this danger becomes a limiting factor in the amount of protection possible or advisable. Negative *g*, through head and neck congestion, produces, in addition, marked discomfort which at levels above —3*g* approaches an unbearable intensity. Finally, there has been noted a certain mental confusion from this stress, for reasons at present not understood.

In tumbling, an increasing problem following escape, be it by bailout, seat ejection, or capsule release, it is possible to produce high alternating positive and negative G. Upon leaving the aircraft the pilot becomes subjected to an extensive decelerative force which intensifies as the velocity of the aircraft is increased. As he tumbles, this force is directed alternately to opposite ends of his body. The forces involved, the physiological effects, and toleration limits are, as yet, unknown quantities.

Transverse and lateral *g*, because the hydrostatic columns are so small, do not produce circulatory difficulties which are critical. In these positions the limiting factor appears to be respiration. When the weight of the thoracic cage exceeds the ability of the intercostal and allied muscles to produce inspiration, effective respiration ceases. This limit averages 12 to 14 *g*.

Another form of acceleration of importance is angular acceleration. When the point of rotation is within the pilot, even small forces of *g* (under 2) may, by affecting the semicircular canals, initiate reflex eye movements. This produces a marked disorientation in the pilot and makes reliance upon instruments even more imperative, especially at night when accurate external visual orientation is impaired.

THE PROBLEM OF VIBRATION

Vibration, in a physical sense, has many of the attributes of acceleration. Reduced to simplicity it is a series of alternating linear accelerations with the greatest change in acceleration occurring at the end of each vibratory wave, when velocity is actually zero. The physiological effects, however, are not determined, primarily, by the amount of acceleration, which is usually small, since the time interval is so short. Instead, the physiological changes are usually dependent upon the amplitude of the swing, measured in inches, and the frequency of these swings, measured as cycles per second (cps).

If the logarithms of these two parameters are compared, the threshold for perception and the limit of human tolerance are essentially parallel. In the high amplitude ranges, both perception and tolerance show an inverse linear relationship to frequency. The physiological sen-

sory receptors of vibration are quite diverse. Certain organs are stimulated by high amplitude, low frequency vibrations, while others respond to low amplitude, high frequency vibrations. There is, however, considerable sensory overlap.

One of the commonest forms of vibration is the high amplitude, low frequency form which produces motion sickness, well demonstrated in children's swings and in the tossing of ships. In aircraft, air currents produce a similar effect termed air sickness. A major difference in this form, however, is that the irregularity of the air currents make the vibration less regular. Such a gross vibration causes alternating mesenteric stretches and otolithic stimuli sufficient to account for the symptoms of which nausea is a predominant one. This discomfort has a lower threshold in the air than other forms of motion sickness because of the added effects of hypoxia (from altitude) and transient cerebral hypemias from the radial *g* of air maneuvers. Because of its irregularity, it is also associated with a buffeting character. By increasing the tendency to fatigue this aggravates the general discomfort of the individual. Myotactic stretch reflexes and skin vibratory sense organs may play a minor role.

These sensory elements usually are more affected, however, by lower amplitude and higher frequency vibrations such as result from the engines and are transmitted through the body of the aircraft. When present they add in the development of a fatigue state. The subsonic vibratory range, with the exception of motion sickness, has so far yielded little evidence of significant physiological impairment. There is some suggestion that certain vibrations, transmitted to the body via skin and bone, may block the normal nerve transmission of vibratory sensations, primarily by stimulating the nerves for such transmission afferent to the sensory end organs. In general, however, much more research is necessary before the final analysis can be made as to the physiological detriment of such vibrations.

As the vibrations reach the sonic range the organ of Corti in the internal ear becomes the primary receptor of the body. The overlap of low sounds in auditory and tactile perception has been well established. It is this overlap in the low auditory frequency range which may play a prominent part in the production of the fatigue so characteristic of this type of vibration. Loud sounds have a similar fatiguing effect and the auditory component in fatigue may possibly be more important than the tactile vibratory one.

In the audible vibratory range the amplitude of vibration, which is measured predominantly as decibels, becomes the limiting tolerance factor. Discomfort at about 120 decibels (1×10^2 — 1×10^6 inches) becomes unbearable and takes a form of intense pain in the ears, probably from the extensive vibration of the sound conducting organs, ear drum, ossicles, and endolymphatic fluid. Hemorrhages have been found in these areas following painfully loud noises. At levels of noise loudness only slightly below tolerance limits, temporary deafness may result from prolonged exposure. In some cases this deafness may become permanent, especially in the higher frequency ranges. Extraneous noise has one further detrimental characteristic for the aviator: it interferes with communications and thereby decreases the safety of both the pilot and the plane.

The part of suprasonic vibrations in the physiological picture is still poorly understood. Data so far available is largely of a spotted nature over the amplitude vs. cps. tolerance curve. The following examples serve as indications of the known dangers of such vibrations:

1. 10,000 cps. of 1×10^2 in. amplitude kill isolated cells.

2. 300,000 cps. of 1×10^5 in. amplitude rupture cellular organisms and fragment their cellular components, kill small fish and frogs, temporarily immobilize mice but do not affect bacteria.

3. 340,000 cps. of 1×10^5 in amplitude produce cardiac rhythm abnormalities in frogs and turtles.

4. 835,000 cps. of unmeasurable but minute amplitudes cause varying vulnerability of nerve tissue cells and bizarre neurological lesions in cats, dogs, and monkeys.

Consequently, the effect of jet and allied engines with suprasonic vibratory frequencies upon the human body can at present only be

hypothecated. No detrimental effects in humans have been attributed unimpeachably to these vibrations up to the present time, but this may well be simply a result of inadequate testing procedures.

The attack on the problem of vibration is likewise incomplete. Various dampening materials can be incorporated to decrease the amplitude of many vibrations, especially in the noise range. Within the cockpit, the pilot appears fairly well protected, also—by materials capable of attenuating high frequency, low amplitude vibrations—from the high-speed engines. The greatest possible danger in this field appears to be to the maintenance crew outside the plane, subject as it is to the vibrations in the air currents from the exhaust tubes.

THE PROBLEM OF FATIGUE

Fatigue as an entity is the sum total of factors, both physiological and psychological, tending to decrease the work performance of the individual as a result of previous work. In general, these factors have been discussed at length under their various headings, as fatigue is only one of their effects. It seems desirable at this point, however, to list these factors briefly as regards the particular part they play in the fatigue picture.

Prolonged muscular exertion has long been recognized as a primary factor in fatigue. Muscular work by aviators is often extensive although a great amount of it may be relatively unconscious. The ever present threat of injury and death produces a mental apprehension, subconscious or not, which is reflected in a state of constant increased muscular tenseness. This tenseness is increased consciously during maneuvers and unconsciously during travel through rough air, which requires the continuous bracing of the body to counteract the buffeting of the airplane. When the pilot is cold, shivering is superimposed on all the other muscular work.

Since the combat of such fatigue is largely a circulatory and respiratory problem of supplying oxygen to the working tissues, anything impairing this supply will increase the fatigue. Anoxia from reduced barometric pressure, especially in a chronic low-grade form, may become quite significant at altitudes where oxygen equipment is not utilized. Radial acceleration during flights involving extensive maneuvers may produce many periods of decreased cranial circulation. More important, from the fatigue standpoint, is the decreased circulatory efficiency from the repeated increased filtration in the stressed capillaries of the legs and abdomen. For both situations, however, the antiblackout suit has proved quite efficient as an antifatigue suit.

Others factors act to produce fatigue by decreasing the body reserves. Dehydration from excessive sweating during prolonged flights in the tropics, or during exposure to excessive radiant heat, is an example of this type. Hunger from missions requiring many hours in the air is another. These may best be combatted by adequate stores of food, drink, and salts in the aircraft to replenish the pilot as they are needed. Proper cockpit ventilation will also aid against excessive temperatures and humidity.

Beside the definite physiological factors present, several psychological factors may develop. Situations involving discomfort may more truly involve both. These include buffeting, cold, heat, hunger, eyestrain (from poor lighting, glare, etc.), poor fitting and uncomfortable clothing and equipment, noise, and vibration. More psychological but still a form of discomfort, although mental, is the constant threat of death and injury, a factor which during combat missions, especially, may become quite pronounced and lead to the symptom complex of *aviator's fatigue,* a form of combat or war fatigue.

Boredom is a most critical factor in the production of mental fatigue. This was well illustrated by the wartime greater incidence of fatigue on the return trips from combat mission. At this time the pilot and crew were no longer keyed-up in anticipation of the coming fight or danger. This fatigue type may be combatted to a slight degree by many minor actions, such as eating an apple or candy bar, drinking fruit juice, or singing. More pharmacologically it can be dealt with by such drugs as caffeine (hot coffee) and benzedrine, which have the capacity to stimulate the cortical cells of the brain and reduce the sensations of fatigue.

The sum total of the means of combatting fatigue are, however, in the last analysis, merely the application of all the means of combatting the various factors leading to the production of fatigue. Since physiological reserve is so important, it is in this field that health, conditioning, and training have some of their greatest practical applications in aviation.

QUESTIONS

The following review questions should be helpful in connection with the preceding text:

1. What are the physical differences between linear and radial acceleration? Give common examples of each in aviation.

2. What are the force vs time relationships commonly seen in linear acceleration? In radial acceleration?

3. Explain the fundamental differences in the effects on the human body of linear acceleration as compared to radial acceleration.

4. Explain blackout.

5. Describe the physiological forces involved in pooling and filtration of blood under radial acceleration.

6. Explain the difference in circulatory and respiratory physiology of positive and negative radial acceleration.

7. What determines the physiological limit of linear acceleration? Of positive, negative, and transverse radial acceleration?

8. Explain the difference in physiological effects of negative radial acceleration upon the face and the contents of the cranial cavity.

9. What are the protective devices used against acceleration and how do they afford protection?

10. What are the sensory receptors for vibration and over what vibratory ranges of amplitude and frequency are they sensitive?

11. What are the detrimental physiological effects of vibration?

12. What protection is possible against vibration?

13. What factors contribute to the state of fatigue of an aviator?

14. What are the means of avoiding or diminishing the fatigue of aviators?

BIBLIOGRAPHY

1. H. G. Armstrong, *Principles and Practice of Aviation Medicine, 2nd Ed.*, The Williams and Wilkins Co. (Baltimore, 1943).

2. Britton, S. W., E. L. Corey and G. S. Stewart, *Effects of high acceleratory forces and their alleviation. Am. J. Physiol.* 146:33-51 (1946).

3. Britton, S. W., V. A. Pertzoff, C. R. French and R. F. Kline, *Circulatory and cerebral changes and protective aids during exposure to acceleratory forces. Am. J. Physiol.* 150:7-26 (1947).

4. Burt, A. S., *Annotated bibliography on the physiological effects of acceleration in aircraft.* School of Aviation Medicine, U. S. Naval Air Station, Pensacola, Florida, 1945.

5. Gamble, J. L., R. S. Shaw, O. Gauer and J. P. Henry, *Physiological changes during negative acceleration.* U.S.A.F., Air Material Command, Dayton, Ohio, MCREXD 695-74L, 25 July 1948.

6. *G Sense*, Office of the Chief of Naval Operations, U. S. Navy, December, 1943.

7. Ham, G. C., *Effects of centrifugal acceleration on living organisms.* War Medicine 3: 30-56 (1943).

8. S. Lippert, *Comprehensive graph for the collection of noise and vibration data. J. Am. Med.* 19:279-286, 1948.

9. Lombard, C. F., *How much force can the body withstand? Aviation Week* 50:20 (1948).

10. R. A. McFarland, *Human Factors in Air Transport Design*, McGraw-Hill Book Company, Inc. (New York, 1946).

11. P. M. Morse, *Vibration and Sound, 2nd Ed.*, McGraw-Hill Book Company, Inc. (New York, 1948).

12. *Orientation*, School of Aviation Medicine and Research, U. S. Naval Air Station, Pensacola, Florida, 1947.

13. *Physiology of Flight*, AAF *Manual* No. 25-2, Headquarters, AAF, Washington, D. C., 15 March 1945.

14. Rushmer, R. F., E. L. Beckman and D. Lee, *Protection of the cerebral circulation by the cerebrospinal fluid under the influence of radial acceleration. Am. J. Physiol.* 151:355-365 (1947).

15. *Anti-Blackout Suits*, Aviation Training Division, Office of the Chief of Naval Operations, U. S. Navy, NavAer 00-80V-67.

16. C. J. Wiggers, *Aviation Physiology*, chapters 28-29, *Physiology in Health and Disease, 4th Ed.*, Lea and Febiger (Philadelphia, 1944).

17. Wood, E. H., E. H. Lambert, E. J. Baldes and C. F. Code, *Effects of acceleration in relation to aviation. Federation Proc.*, 5:327-344 (1946).

CHAPTER 4

OPHTHALMOLOGY IN AVIATION MEDICINE *

EDITOR'S NOTE.—Recent changes in the *Manual* of the *Medical Department* have not been included in this chapter. Other changes will be made from time to time. Reference should always be made to a currently corrected copy of the *Manual* of the *Medical Department*, U. S. Navy for existing physical standards and procedures.

INTRODUCTION

Probably the most important function of the flight surgeon, as far as ophthalmology is concerned, is the conduction of that portion of the flight physical examination related to the eyes. It is essential that any pathology be detected which might interfere with the proper performance of flight. It is also desirable to predict any condition which might become worse. It is undesirable both from the point of view of the Government and of the individual for a candidate to spend many months in expensive training only to find that he has developed a defect which will preclude his designation as a naval aviator. The technique of the flight physical examination will therefore be discussed. We will also endeavor to explain why certain physical standards are set for the qualification of the candidate for flight training.

It is quite obvious, even to medical students, that the more profound the knowledge of anatomy and physiology, the more interesting and understandable becomes the pathology. The limitations of time and space will permit only a brief discussion of these basic sciences. The reader is urged, if time is available, to scan through *The Anatomy of the Eye and Orbit* by Wolff and to study the excellent anatomical transparencies presented in McHugh. The discussion on muscles will be much more interesting if you have the anatomy well in mind.

Of course a good flight surgeon will be able to offer the maximum amount of clinical care in regard to common complaints, which are no different in aviators than other people. The more problems the flight surgeon can handle within his own squadron the more confidence he will share with his airmen. The daily visits involved in handling minor complaints gives the flight surgeon close and invaluable contact with the personnel of his squadron. "*Diseases of the Eye*" by May, has a wealth of material packed into not too many pages. The author is a master of word efficiency. You probably have read it in your medical school days. Try to read it again—even the fine print on anatomy and physiology at the beginning of each chapter. It will help you understand how to handle minor eye conditions and make you confident as to when to call for assistance. The experienced medical officer knows when a consultation is desirable and should never hesitate to call for one if circumstances so indicate. Such measures will not destroy the confidence of your squadron in your professional ability. Your efforts will be conducive to gaining confidence and good will.

VISUAL ACUITY

An accurate testing of visual acuity is more valuable than any other single test in the examination of the eye. We all consider that 20/20 means vision is normal. That is generally true but why do some people read 20/15? Failure in visual acuity is the most common cause for failure of flight physical exams. The subject is worthy of considerable thought.

To take visual acuity a patient is placed preferably 20 feet from a group of test letters. The smallest letters read correctly, without hesitation, indicates the visual acuity. A few letters missed on a line may be ignored if the

* Prepared by John T. Smith, Capt. (MC) USN and George W. Rand (MSC) USN.

candidate reads an equal number of letters correctly on the next smallest line. Visual acuity is recorded as a fraction but it is not really a fraction. $\frac{10}{20}$, which is also written as $\frac{20}{40}$, is not 50 percent of normal vision; it is 80 per-

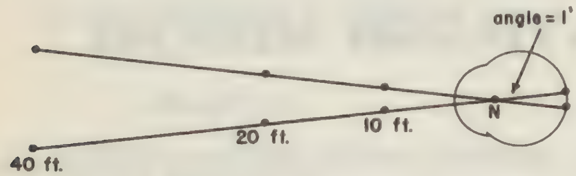


Figure 4-1.—The greater the distance from the nodal point the farther apart must two points be to subtend a 1 minute angle at the nodal point. (N)

cent of normal vision. The recording of visual acuity is nothing but a shorthand way of saying, "The person was placed 20 feet from the vision chart and read only the size letter that a normal person could read at 20 feet."

$$\frac{\text{Distance of patient from letters.}}{\text{Distance for normal eye for the size letter used.}}$$

The manner in which these letters are prepared is of interest in understanding the physiology of vision.

One essential factor in normal visual acuity is the resolving power of the retina. Fundamentally, the resolving power of a retina is the ability to distinguish two points as such at a given distance. To accomplish this the image of each point must fall on the retina in such a manner as to be separated by at least the width of a single cone cell ending. This ability depends upon several factors, only two of which are the actual width of a person's cones and

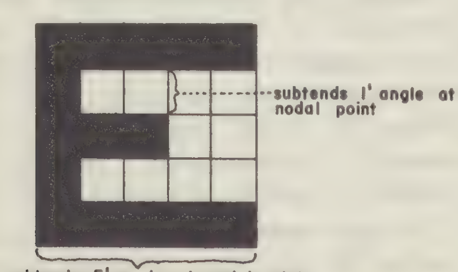


Figure 4-2.—The entire box subtends a 5' angle for any distance. Each small box subtends a 1' angle.

the range of physiological nystagmoid movement for a given individual. This complicated physiological phenomena can be summarized in a single statement for the normal eye: when the visual lines of any two points make an angle of 1 minute or more at the nodal point of the eye they are distinguished as two points on the retina. (figure 4-1.)

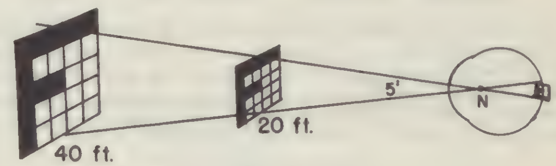


Figure 4-3.—Each letter subtends a 5' angle at the nodal point (N). Each point of separation of the letter subtends a 1' angle.

For the preparation of test letters the amount of separation of two points whose visual lines subtend a 5′ angle at the nodal point is figured for any particular test distance. A square is outlined using this measurement as any one side. The square is then subdivided into 25 smaller squares. These smaller squares are used as a guide in the preparation of test letters. It is obvious that such letters will possess portions that subtend a 1′ angle on the retina and the separation must be recognized in distinguishing the characteristics of any particular letter. (figure 4-3.)

The most common method of recording vision in the United States is the Snellen system which entails a vision test card which has letters of various sizes. Each letter, however, has distinguishing separation spaces which subtend the 1′ angle for the particular distance which the letter represents; that is, 200 feet, 100 feet, 70 feet, 60 feet, etc., down to 10 feet. (The patient remains at 20-foot distance throughout the test.) The other system, called the Grow system, used on Navy forms for many years, entails a card which bears many lines of letters, all the same size, and of such size that the distinguishing separation spaces subtend the 1′ angle for 20 feet. In using this type card, the patient must be moved closer or farther from the chart to obtain a recording.

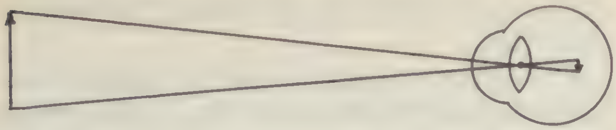


Figure 4-4.—Myopic eye or long eye at rest, focuses distant objects in front of the retina.

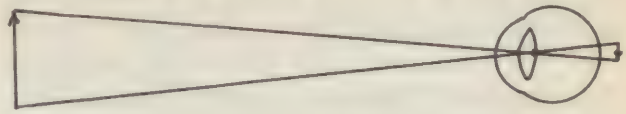


Figure 4-5.—The hyperopic eye or short eye. At rest, distant objects come to a focus behind the retina.

The Snellen system entails keeping the patient at a constant 20 feet throughout the test and changing the size of the letters. The Grow system entails keeping the size of the letters constant and changing the distance of the patient. Visual acuity, therefore, is a shorthand expression which is written like a fraction.

$$\frac{\text{Numerator}}{\text{Denominator}} \qquad \frac{\text{Distance of patient}}{\text{Size of letters.}}$$

The faculty of normal resolving power is only one factor necessary for normal visual acuity. Resolving power is of no avail if the eye is so defective in focusing as to produce a blurred image on the retina. A profound discussion of the subject of refraction is beyond the scope of this paper. The flight surgeon should know that myopia is the most common reason for failure of a candidate to pass the original examination for flight training. Myopia also takes its toll of candidates during flight training. Astigmatism is also a bugaboo for candidates. However, astigmatism is not usually progressive. Once a candidate enters the training program astigmatism seldom is a cause for disqualification.

Most cases of myopia are caused by the fact that the eye is too long for its refractive power. At complete rest such an eye would focus a distant object (test letters at 20 feet) in front of the retina. (figure 4-4). No amount of effort can change this situation for what is needed is not effort but relaxation. This individual is trying to relax his ciliary muscle and make his lens flatten out more. He is trying to drop the image back to the retina. Candidates for aviation often fall into the hands of charlatans who claim they can *train* a myope to read normally. It is true that many honest scientists are trying experiments which they hope might cause the myope to flatten out his lens at rest. But so far all these experiments have failed. None of these honest workers make any promise to cure myopia or to "get the candidate by the exam."

But the reader may say to himself "I happen to know of a fellow who failed his examination because of myopia and then took this or that training and exercise and then passed the examination." It is not possible to go into detail here about such cases. However, all these stories, if fully investigated, prove false. To the present date *no cure for myopia is known.* Correction by glasses or contact lenses—yes! However, it has not proven economical to the present writing, to invest $75,000 in training a candidate who needs glasses or contact lenses to see clearly.

All babies are born hyperopic or far-sighted. Their eyes are too short to focus even a distant image on the retina. When the lens is completely relaxed a distant image is focused behind the retina. (figure 4-5.) They see clearly only by accommodating the lens.

As the child grows, his eye grows longer. If the growth stops short (hyperopia) or at just the right length (emmetropia) the individual goes on through life able to see clearly for distance, provided. of course. that his resolving power is normal. If the eyeballs grow too long they become myopic. This occurs early in some individuals. Most myopias however, become manifest between the ages of 16 and 23 years. This is the age when candidates present themselves for flight training. Often candidates slip through the aviation physical examination and start their training. The lengthening of the eye ball continues. Too many candidates who start flight training fail to complete their training because the final lengthening of the eye ball occurs while they are still in training. Since almost 20 percent of Americans become myopic

by the age of 23, this defect is a very great problem in the selection of candidates for flying. We could avoid this loss if we permitted only moderate hyperopes to start training. This, however, would so limit our field of selection that many fine candidates would be lost. Up to the present time it has been deemed impractical to so limit the field of selection.

But there is a long range reason for limitations even among hyperopes. The modern aviator does much of his flying by instruments. He must read charts and navigate. All this requires close work. Hyperopes fail in close work much earlier in life than emmetropes. The higher the hyperopia the earlier the failure. An aviator who requires bifocal lenses is not qualified for unrestricted flying. Therefore, a high hyperope might have 5 years cut off his period of usefulness as an unrestricted flyer.

The true refractive nature of an eye can only be determined by doing a cycloplegic refraction. All fully qualified flight surgeons are able to do this type of examination.

For the many medical officers who cannot refract, but who must conduct preliminary physical exams at isolated or distant ships or stations, a careful visual acuity test must take the place of a cycloplegic refraction.

The task of taking visual acuity should not be delegated to persons of doubtful ability or reliability. The instructions in the Manual of the Medical Department are important enough to justify summarization here:

1. Use standard Snellen letters provided by any reliable manufacturer.
2. Have patient seated 20 feet from chart.
3. Provide equivalent of a 200-watt light thrown on the chart from 4 feet distance.
4. Do not give the candidate a chance to memorize your eye charts. Change them frequently.
5. Test the right eye first.
6. Reading without hesitation means reading the 10 letters in 5 seconds.

Medical officers will spare candidates severe disappointment if they will arrange for a cycloplegic refraction of all candidates who have doubtful visual acuity. Candidates for flight training must read 20/20 without mistake or hesitation.

It would be wise, if there is the slightest hesitation in reading 20/20 for the medical officer to put a plus 0.25 dropter sphere in front of the candidate's eye. If this blurs the 20/20 line, a refraction under cycloplegic should be done if at all possible.

Once a flyer has his wings he is allowed to continue unlimited flying as long as his visual acuity is 15/20 or better, unaided by glasses. This is not an inconsistent standard. We want to induct into training only candidates whose vision is excellent. Once an aviator is fully trained and experienced he is able to compensate for a slight loss of visual efficiency.

For those who are familiar with the cycloplegic refraction—the acceptable limits of refractive error are as follows:

1. Not more than 0.50 diopter of myopia in any meridian.
2. Not more than 0.50 diopter of astigmatism in any meridian.
3. Not more than 2.00 diopters of hyperopia in any meridian.

In conclusion, a test of visual acuity is truly a test of a complicated mechanism. If we assume that the optic tracts and radiations are all normal, the visual acuity is determined by:

1. Resolving power.
2. Ability to focus an image clearly.
3. The clarity of the media of the eye.

The term 20/15 indicates better than average vision. It is useful to refractionists who wish, of course, to correct refractive errors in such a way as to provide the patient with the best vision that his visual system is capable of attaining. To the flight surgeon, it has little known significance. Perhaps someone should run a series of tests comparing the capabilities of aviators who have 20/15 vision with those who have a mere 20/20 vision.

There are several possibilities to explain 20/15 vision. They are listed as follows:

1. The persons cone cells are smaller.
2. The persons media are clearer.
3. The persons psychological processes are sharper.

It is generally accepted that the rare cases of apparent improvement obtained from visual training courses to improve visual acuity are

attributed to the third factor. The individual gazes at test letters daily until he has learned that a certain type blurr on his retina is an "E," another is "H." The best results of this type training are attained with persons whose vision is very low; (i.e. 20/100 to 20/60) and whose intelligence and power of observation is very high. It is rare to raise a patient from 20/25 to 20/20. Even if this is accomplished and the candidate "slips through" the flight physical, he will never complete the training program. The very myopia which caused the need for training exercises will increase during training. It is estimated that 98 percent of those persons who "jam" their way into flight training by such methods become more myopic during the training course and at some time or other must be dropped from the program.

Test visual acuity carefully:

REVIEW QUESTIONS

1. What does the expression $\frac{20}{40}$ mean when written out in full?
2. What does $\frac{15}{20}$ mean when written out in full?
3. About how much loss of visual efficiency does 20/40 indicate?
4. What is the normal minimum visual angle?
5. Where does the image of a distant object fall in relation to the retina of a myopic eye?
6. What can a myope do, through his own effort, to improve his distant vision?
7. What is the most common cause for failure to pass the visual acuity test for flight training?
8. At what age does myopia usually stop its progression? Give a reason.
9. Why is a high hyperope undesirable in aviation?
10. What factor or condition of the eyeball itself can cause lowered visual acuity?

ACCOMMODATION

Accommodation should be an interesting subject to all Americans for eight out of every ten, if they live long enough, will some day be embarrassed by the inadequacy of their accommodative power.

When a person who sees clearly in the distance (reads 20/20 on the eye chart) shifts his gaze to some near object, a momentary blur occurs due to the fact that the image of the object looked upon falls behind the retina. This momentary blur sets up a stimulus which causes the ciliary muscle to contract and the focus is brought forward just enough to put the image on the retina.

It is obvious that the myope with long eyes requires less dioptic power to accomplish this focus of near objects than the emmetrope. The hyperope, on the other hand, needs much more power than the emmetrope.

Let us set aside the many theories for explaining accommodation and accept the fact that an increase in needed dioptic power is accomplished by contraction of the ciliary muscle and a resulting bulging of the crystaline lens.

Furthermore, the amount of dioptic power which a person is able to produce by contraction of the ciliary muscle is fairly uniform for normal eyes of a given age. This is true regardless of whether an individual is a myope, emmetrope or hyperope. It is also accepted that the ability to produce such dioptic power decreases with age. Persons may succeed by fair means or foul to hold back the effects of age on their outward appearance but the loss of accommodation which accompanies age is normally as certain as the daily rise of the sun.

Accommodative power is determined by employing a card which bears the smallest size print that the patient is capable of reading. The card is held very close to the eye and slowly moved away until the patient is just able to read. The distance of this point from the eye permits, by calculation, an expression of the dioptic power produced.

Dioptic power is the reciprocal of the focal length expressed in meters. If a person with no refractive error (an emmetrope) reads very fine print at 10 cm. it is assumed that his own lens has bulged sufficiently to produce the same effect as a lens of 10 cm. focal length. Since 10 cm. is 1/10 meter, the power of lens necessary in this case would be the reciprocal of 1/10 or 10 diopters.

A special rule called the Prince rule is provided for aviation physical exams. The calculation has been done by the manufacturer and the examiner can read off his finding in terms of diopters. The tip of the rule is placed 11.5 mm. in front of the cornea. A card of fine print is placed close to the eye and gradually moved away until the print is legible.

A reading which is much lower than the average for the age of the particular person is due to:

1. A very high hyperopia (over 2 diopters).
2. The presence of pathology such as iridocyclitis, glaucoma, diabetes, or toxemias.
3. Paralyzing drugs such as homatropine which might have been used by a candidate bluffing his way past the examination. (It flattens the lens and often improves a myopic condition.)

Any of these situations would be undesirable in a naval aviator. With this in mind the standards for qualifications require that the accommodation reading for each eye must be within 3 diopters of the average for the age of the examinee.

The following is a table of average accommodation at various ages.

Age	Diopters	Age	Diopters
18	11.9	25	10.2
19	11.7	30	8.9
20	11.5	35	7.3
21	11.2	40	5.9
22	10.9	45	3.7
23	10.6	50	2.0
24	10.4	70	0.5

Most people must bring average newspaper print to 33 cm. from the eye in order to read the print clearly. This means the eye must develop 3 diopters of accommodation over and above their distant correction. A glance at the table will make it obvious that somewhere between 45 and 50 years of age 3 diopters can no longer be produced and in most cases glasses must be worn for reading clearly. This stage, at which reading glasses are needed, comes on much earlier for hyperopes and later for myopes.

REVIEW QUESTIONS

1. Briefly, how is accommodation accomplished in the human eye?
2. What is the total dioptic power of accommodation which the average 18-year-old eye is able to produce?
3. What is the total dioptic power of accommodation which the average 45-year-old eye is able to produce?
4. In testing accommodation, do you move the card toward the eye or away from it?
5. If a person 18 years old was hyperopic to the extent of 1 dioptic, how much accommodation should be shown on a test rule?
6. If a 45-year-old person is myopic to the extent of 3 diopters, how much accommodation should be shown on a test rule?
7. How much accommodation is required for a person to be qualified for flight training?
8. Why is adequate accommodation necessary for an aviator?
9. Name a few causes of inadequate accommodation.
10. How much accommodation must an emmetrope produce in his lens system in order to read clearly at 33-1/3 cm.?

PHORIAS AND THE PHOROMETER

When a person fixes his eyes on an object or changes his gaze from one object to another a series of rapid events occur. One eye becomes the fixing eye. (This fixing eye is usually constant for most people. A small percentage of persons alternate the eye which is chosen for the fix.) As soon as the assigned eye fixes, it has taken such a position as to put the macula, the nodal point of that eye, and the object fixed upon, in one line. The other eye, unless it by chance is already fixed, receives the image of the object on a part of the retina off the macula. The result is either blurred vision or a momentary diplopia. Either one of these conditions causes a stimulation of the fusion center with a resulting motor response to shift the nonfixing eye so that it too has the object, the nodal point and the macula in line.

These events occur so rapidly that neither the person fixing or an observer can readily detect the movement. That portion of the brain which reacts to the stimulus of blurring or diplopia is called the fusion center. Physiologists do not know where it is located, but the facts indicate that such a center exists.

When the fix has once been accomplished it is held by the normal human as long as he desires. Some eyes have a neuromuscular balance which might be compared to a well balanced window and sash weight—the fix remains, by muscular balance, with little effort. Such a person is said to be orthophoric or demonstrates orthophoria. The eyes of most individuals, however, have a tendency to turn or drift up, down, in, or out. This tendency to drift is usually due to over tonicity of one or

two muscles or undertonicity of their antogonists. Although this tendency to drift is present in most people, the actual drifting seldom takes place. This is explained by the constant balancing neuromuscular effort which is stimulated by the fusion center.

Phoria, therefore, is defined as a tendency of the eyes to drift off from a fixed object, which tendency is fully compensated and, therefore, is only detected by the use of a special diagnostic technique.

It is logical to assume that a person who has a tendency to drift, and who maintains for long hours a compensating muscle stimulus so as to prevent the actual occurrence of drifting, will eventually tire. The result will be either a breakdown of the fix and a resulting diplopia or a psychic strain which will manifest itself as headache, vagus discomfort, and a loss of efficiency. The degree of discomfort and the rapidity of its onset depends on the degree of phoria. It is obvious that in seeking candidates for aviation certain limits of phoria must be avoided. For this reason the flight surgeon must acquire the technique and understand the use of the phorometer. This instrument is generally accepted as the most efficient and accurate means of measuring phoria.

Esophoria is the tendency of the eyes to turn in. It is due to overaction of the internal rectus muscles or underaction of the external rectus muscles. That statement does not help us much, for it is obvious. The big question is why do these muscles overact or underact? The answer to that is a little beyond our scope. However, here are a few possibilities:

1. A young man is astigmatic and goes through high school not knowing that he needs corrective lenses. During his long hours of study he brings the book closer to his eyes so as to make the blurring caused by astigmatism less annoying. This calls for constant convergence and a resulting increase in strength of the internal rectus muscles. He, therefore, may develop an esophoria for distance. The same young man, when his internal rectus muscle becomes fatigued and quits, would show an exophoria for near. In other words, esophoria is a tendency to converge more than the fixing point requires. Exophoria is a tendency to failure in producing the amount of convergence needed for a definite fixation point.

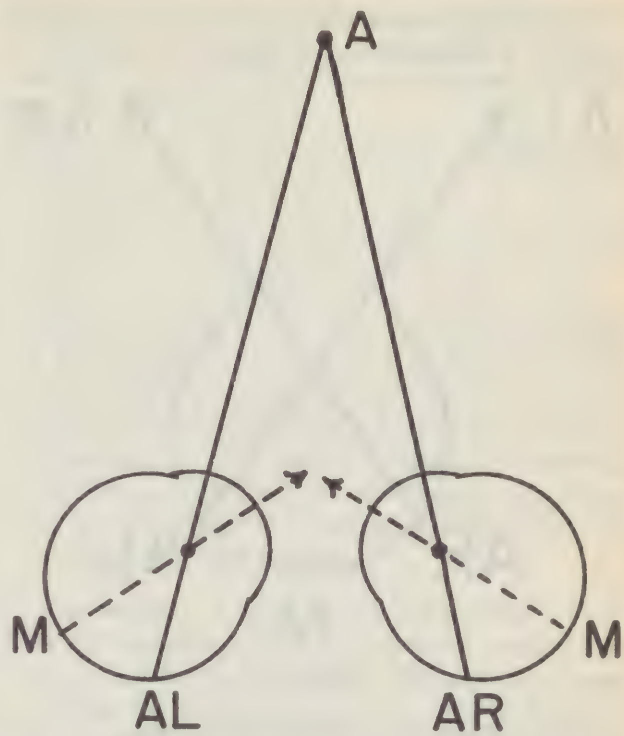


Figure 4-6.

Hyperphoria is the tendency of one eye to turn up in relation to the opposite eye.

Esophoria, when not avoided by the fusion center, will cause the patient to experience homonomous diplopia. Figure 4-6 shows how the retinae are stimulated.

A pair of eyes is trying to focus on A. They fail to do so because they have a tendency to turn in which, let us say, an exhausted fusion center can no longer correct. The image in the right eye hits the retina inside the macula. The image in the left eye hits inside its macula. These points are far from being corresponding. The final concept of two eyes stimulating one brain is diagrammed in figure 4-7.

Recall that commissural fibers mold the maculae of each eye and all other corresponding points into one psychological concept.

A little thought will allow you to understand why, in an effort to depict physical and psychological phenomena in one diagram, some license must be granted. Note that the psychological projection doubles the physical distance of the stimulus off the macula. (figure 4-8.)

Exophoria, when not corrected by the fusion center, produces crossed diplopia (figure 4-9.)

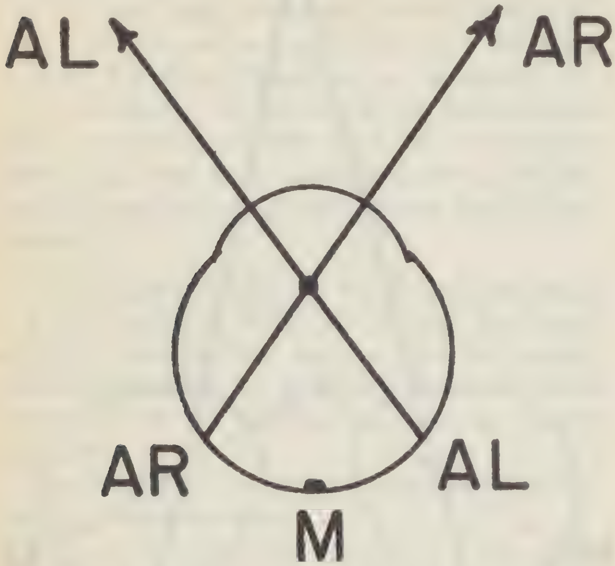


Figure 4-7.

Again recall, the commissural fibres in the brain mold corresponding points into one concept. You work it out for hyperphoria using this same logic.

It has been shown that the fusion center of the brain maintains a constant "watch" preventing any tendency of the eyes to drift off the fix. To determine the presence of any such tendency one must weaken or paralyze

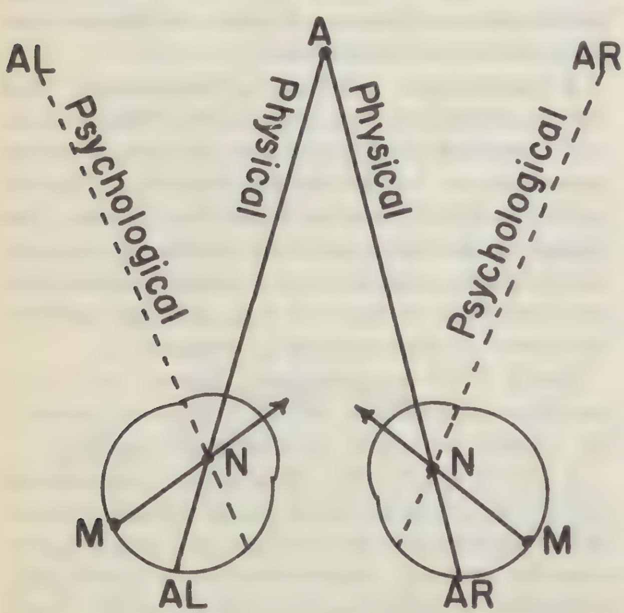


Figure 4-8.—Homonomous diplopia.

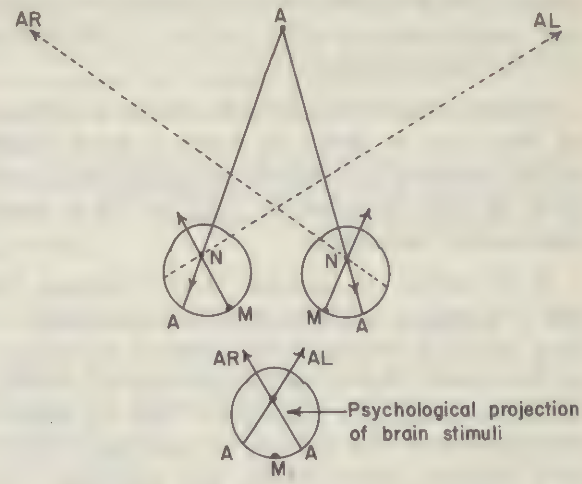


Figure 4-9.—M = Macula, N = Nodal point, AR = Projection for right eye, AL = Projection of left eye, A = Point of stimulation.

the fusion center. One obvious way to remove the effectiveness of the fusion center is to give a general anesthetic. While the person is in the first stage of a general anesthesia the eyes will drift in accordance with this tendency. By this observation we could learn the character of the phoria but we would have no way of measuring the amounts. You might also get the examinee drunk. Such a method might be pleasant but impractical.

We are therefore forced to seek some way to remove the influence of the fusion center without disturbing any other part of the neuromuscular mechanism. This can be done by not paralyzing the center but by so "discouraging" the center as to make it ineffective. There are three quite practical methods of accomplishing this.

1. Change the color of the two retinal images; that is, make one red, the other white.
2. Shorten the exposure time in which the two eyes can work together. This is done by covering one eye, and by a series of uncoverings, of short intervals, to attempt to catch the patient before the correcting "fix" reflex is completed.
3. Change the shape of the image at the two retinae. There are many methods of accomplishing this but to save time we will mention

only the most practical method: that is, a Maddox rod is placed before one eye while the examinee looks at a small round, almost point source of light about 20 feet away. (The small light, often called a muscle light, is a part of all modern eye test charts). The Maddox rod is nothing more than a very powerful cylinder. As a matter of fact, the simplest ones are made by snapping a short piece of a glass stirring rod into a black blank.

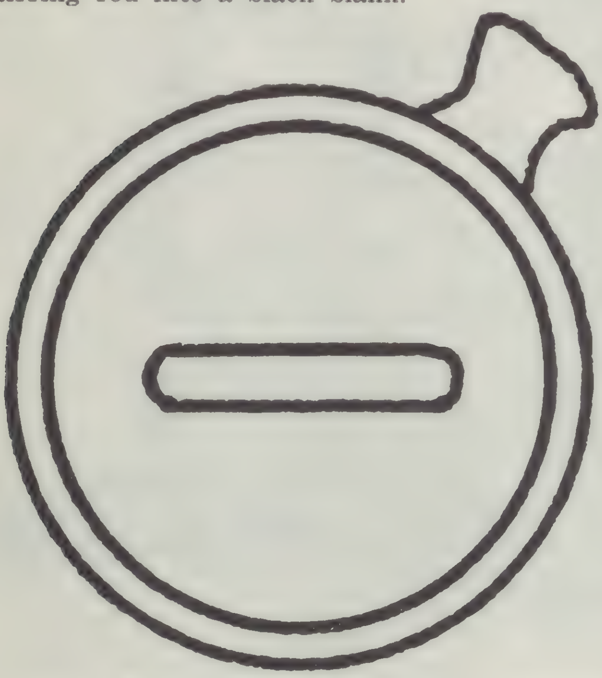


Figure 4-10. Simple Maddox rod.

When a simple Maddox rod is held before one eye with the axis of the rod horizontal the eye behind the Maddox rod sees a fine line vertical in position. The other eye sees the small light which is fastened to the wall. In other words, the shape of the object is different for each eye. The urge to fuse the two is greatly decreased.

It is obvious that the use of all three of these methods or a combination of two of the three methods does not completely remove the effect of the fusion center. However, the fusion center is so discouraged by these methods that for all practical purposes it may be considered as out of the picture.

With the controlling influence of the fusion center so suspended, the eyes of the examinee drift just as they have a tendency to drift. The actual determination of the type of the drift is revealed by subjective response of the examinee. The examinee describes to the examiner the false protection which is produced by the drifting eye.

Finally, by the use of prisms placed in the proper position, the examiner is able to determine the extent of the drift in diopters. Obviously, a drift is as great as the prism dioptic power necessary to correct its effect.

Measurement of phorias.—For actual study of this subject the student should have access to a modern phorometer such as the one pictured in the accompanying diagram. If such an instrument is not available then an ordinary trial frame, a Maddox rod and a series of prisms can be utilized by the student to appreciate the effect of the phorometer.

Description of the phorometer.—Most modern phorometers are supported on a cross bar which in turn is fastened to a floor stand. There is usually a gear mechanism provided to move the supporting bar back and forth in the horizontal plane and another to raise and lower the upright member which supports the crossbar. Usually, before any adjustment can be made by either gear mechanism, a thumb screw must be released. When adjustment is made so that the phorometer is fitted snugly before the face, the locks must be tightened to prevent any movement during the test. It is especially important that the crank for raising and lowering the vertical member be held in one hand while the lock nut is fastened. Failure to take this precaution might result in the upright member sliding down by its own weight and causing a painful blow on the nose of the patient. Another precaution for the preservation of this very useful instrument is a warning to never attempt to move or adjust the moving parts of the phorometer without first releasing the lock mechanism. Forcefully moving the adjustment arms against the hold of the lock can strip the gears and do damage to the instrument.

The basis of the phorometer itself is a heavy metal trail frame which is provided with grooves to accept three lenses and provision for rotating the axis of cylinders. There is also a lever for adjustment for the interpupillary distance of this frame. In front of each aper-

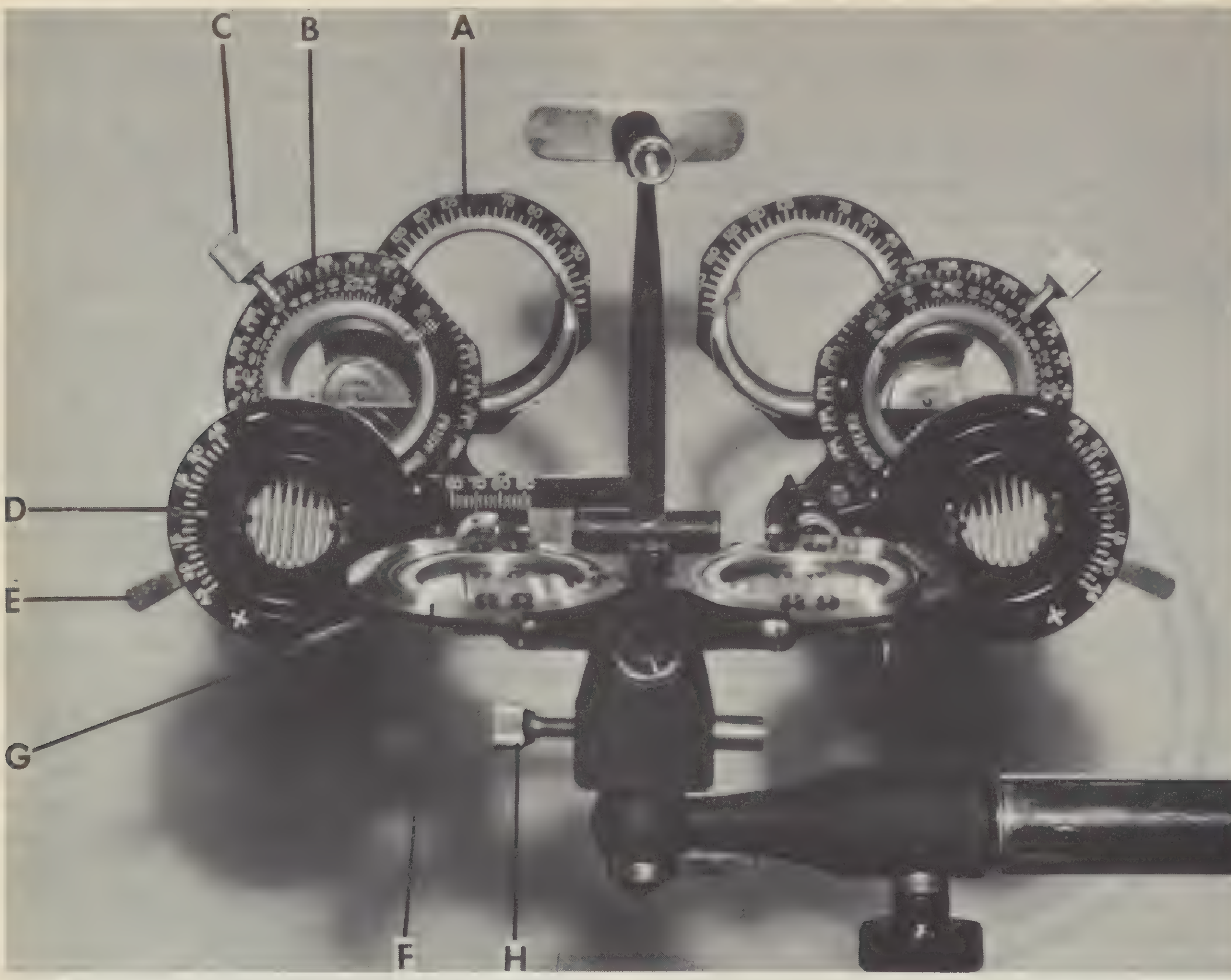


Figure 4-11.—PLATE 1. THE PHOROMETER.

A — Trial frame
B — Risely prisms on zero position
C — Thumb screw for adjusting Risely prisms
D — Multiple Maddox rod
E — Adjustment lever for Maddox rod
F — Stephens prism
G — Adjustment lever for Stephens prism
H — Adjustment screw to Level Phorometer

ture of the trial frame, a rotating Risely prism is suspended in such a manner that the prism mechanism can be put in place before the eye, or, when not in use, can be flipped down to the side.

Some knowledge of the working of a Risely prism is desirable. It consists of two 15-diopter prisms placed in contact and provided with a set of gears which are so adjusted that when one prism is turned clockwise the other turns counterclockwise. A thumb screw is provided to facilitate this rotary movement. In one position the prisms lie base to base and so produce a total of 30 diopters of prism power. Turning one prism through 90° would cause the other prism to move in opposite direction 90° and the result is two prisms apex to base. The total result of this combination is zero or plain thick window glass. By rolling the thumb screw on the Risely prism any effect from zero to 30-prism diopters can be obtained. When the thumb screw of the Risely prism is directly vertical and kept in this position the rolling of the prisms against each other makes possible any amount of base-out or base-in from zero to 30 diopters.

By turning the thumb screw 90° outward to the horizontal position, the Risely prisms are so placed as to be able to create from 0 to 30 diopters base-up or base-down. The Risely prism is seldom used in this base-up or base-down position as will be shown later. It is well

Figure 4-12.—Determining the fixing eye.

to note, however, that by making use of the prism on the opposite eye frame, it is possible to develop as much as 60 diopters, base-in or base-out.

Students often have difficulty in remembering which position of the thumb screw produces a base-in or base-out effect and which position produces base-up and base-down. We would call your attention to the fact that when the marker of the Risely prism is on 2 you are producing 2 prism diopters. When it is on 15 you are producing 15 prism diopters. If the thumb screw is so turned as to produce 30 prism diopters the bases of the two prisms will be in contact with each other. In this situation it is quite obvious what "base" position you have been producing as you turned the thumb screw without disturbing the actual location of the thumb screw.

Just in front of the Risely prism, and on each side, is a Maddox rod. This can be pushed up in front of the trial frame and, by making use of a tiny handle, the position of the axis of the rods can be changed at will.

The Stephens prisms, the operation of which will be described later, under the technique for measuring hyperphoria, are so arranged that a prism can be thrown up before each eye in a single movement of the frame which carries them. These prisms are usually used only when base-up or base-down effect is desired.

Technique for using phorometer.—The first step is to determine the fixing eye. This is done by punching a 1-cm. hole in a large library

Figure 4-13.—Phorometer is being adjusted. The right hand turns the crank to raise and lower the entire apparatus. The left hand guides the head into place.

card. The examinee is told to hold the card in both hands and to extend his arms fully in front. The card is placed in such a position as to permit the examinee to sight the small muscle light on the wall ahead of him. While the card is thus held the examiner covers one eye. If the examinee no longer sees a light you may assume that the eye chosen for cover is the fixing eye or vice versa.

Next the Risely rotary prism is brought before the *nonfixing* eye. The marker must read zero and the thumb screw must be shifted to the exact vertical position. With the thumb screw in this position the mere rolling of the thumb screw will produce prism base-in or prism base-out effect, depending upon the direction of the roll.

A Maddox rod is now snapped in front of the *nonfixing* eye in such a way as to have the rods in the horizontal position. This will cause the light entering the *nonfixing* eye to appear as a thin vertical line. (The multiple Maddox rod used in most phorometers is nothing more than a series of glass rods piled one above the other. It has exactly the same effect as a simple Maddox rod, but due to its multiple nature, exact centering a single rod is spared. In short, it is a time saver. If the manufacturer supplies a red colored Maddox rod it is obvious that only a small card used in covering and covering the *nonfixing* eye will permit the use of the three practical methods of breaking up the effect of the fusion center.

With the fusion center thus broken, the eyes drift. With the Maddox rod in this position we are ready to determine the presence or absence of any horizontal phoria; that is, esophoria or exophoria.

While the examiner allows the examinee to have momentary exposures of the *nonfixing* eye, the examinee is requested to report where he sees the vertical line in relation to the round light.

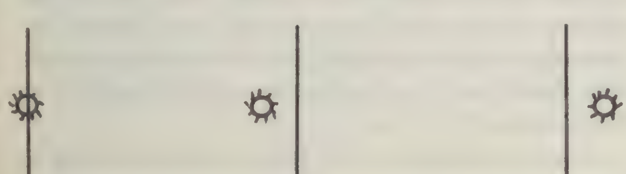


Figure 4-14.

It is obvious that the examinee must report one of these three possibilities.

The interpretation of this response must be made only after the examiner has taken mental note of which eye is behind the Maddox rod. In other words, which eye is represented by the line? Which by the light?

If the line is reported to be through the

Figure 4-15.

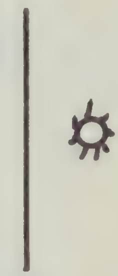


Figure 4-16.

light no horizontal phoria exists. In such event esophoria is zero and exophoria is zero. Such a finding is rare.

If the Maddox rod is before the right eye and the patient reports this the examiner concludes that esophoria homonomous diplopia is present. The short periods of uncovering of the *nonfixing* eye are continued while the prism power base-out is gradually increased. When the patient reports the line to be through the light the examination is complete. The Maddox rod is flipped out of place and the amount of esophoria is read off in prism diopters and recorded.

If the patient reports this, exophoria crossed diplopia is present and the Risely prism is turned so as to produce a base-*in* effect. When the line is reported as passing through the light, the amount of exophoria has been determined and is read off at the marker on the Risely prism.

Notice that crossed diplopia indicates exophoria and an uncrossed or homonomous diplopia indicates esophoria. (figure 4-8 and 4-9.)

A simple noematic is here suggested by spelling

e X ophoria

The capital X might help to remind you that exophoria produces *crossed* diplopia. If the Maddox rod is before the right eye and the ex-

Figure 4-17.—Taking lateral phoria measurement. Note the thumb screw of the Risely prism is in vertical position. The eye is uncovered only for short intervals by raising the card.

Figure 4-18.

aminee reports the line to the left of the light the diplopia is obviously a crossed type.

No person can have both esophoria and exophoria for the same point of fixation at the same time. To report such a situation will display either carelessness or ignorance on the part of the examiner.

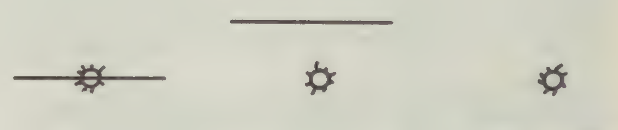


Figure 4-19.

The Maddox rod is now replaced to a position in front of the *nonfixing eye.* The direction of the rod is changed so that the axis of the rod is vertical. The covering and short exposures of the *nonfixing* eye is again resumed. The examinee now indicates one of these three conditions.

Again remember that your interpretation of the examinee's response depends upon which eye is behind the Maddox rod.

Figure 4-20.—Taking Vertical phoria measurement. Only the Stephens prism is being used. The eye is uncovered for short intervals by dropping the card.

In regard to vertical phorias only three possibilities exist:

1. Right hyperphoria
2. Orthophoria (no phoria)
3. Left hyperphoria

The term hypophoria is hardly ever used in ophthalmology. If you consider that a person possesses the tendency for his left eye to drift down in relation to his right eye you may describe the same phenomenon by stating that the right eye has a tendency to drift up in relation to the left eye. Left *hypo*phoria is the same as right *hyper*phoria, just as six is the same as half dozen. This is a mind twister which students find it hard to appreciate. Think it over. It is an accepted ophthalmological fact.

Now let us return to the response of our examinee. The Maddox Rod is now with its axis vertical. If the patient sees the line through the light you may conclude that no phoria is present. This is recorded.

R. H. (right hyperphoria) = zero
L. H. (left hyperphoria) = zero

If the patient reports this

Figure 4-21.

Reflect for a moment: the right eye is behind the Maddox rod. It is obvious from the above response that the line of the Maddox Rod must be falling on the retina of the *right* eye *above* the macula. If this is so then the right eye must be turned up in relation to the left eye—hence a diagnosis of *right hyperphoria.*

Now we must determine how much prism is necessary to correct this discrepancy. A prism placed *base-down* before the *right* eye will accomplish this correction. When you add enough base-down prisms before the right eye to move the retinal image of the line down to meet the right macula the patient will see this.

Figure 4-22.

The amount of prism employed will indicate the extent of the hyperphoria in prism diopters. If under the same conditions (that is, Maddox rod before the right eye) the patient reports the line above the light.

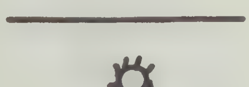


Figure 4-23.

Your diagnosis is *left hyperphoria* and the extent will be indicated by the amount of prism *base-up* before the *right* eye as is necessary to correct the discrepancy. The noematic for vertical phoria is—

"The lower image indicates *hyperphoria* of the eye which that image represents."

At this point we must call your attention to the fact that any vertical phoria which is of such a character as to be corrected by a 2-diopter prism base-down before the right eye and no prism before the left eye: such a phoria can also be corrected by two diopters base-up before the left eye and no prism before the right. Furthermore, the proper correction may be equally divided before each eye; in this example, one diopter base-down before the right eye and one diopter base-up before the left eye. Expressed in symbols:

2 ▽ left = 2 △ right = 1 ▽ left with 1 △ right

This fact is employed in the modern phorometer in the form of a Stephen's prism. These prisms are usually 1 prism diopter each and are mechanically set so that when one is base-down the other is base-up. Therefore, in rotating these prisms, one against the other, any amount of correction from zero to 2 prism diopters may be accomplished.

It is obvious that, when you have used the Stephen's prisms to their maximum, and still have not measured the full extent of vertical phoria present, you will have to augment the Stephen's prism with the Risely prism. Before such augmentation is possible you must set the Risely prism in such a way that it will produce base-down or base-up effect; that is, the thumb screw must be horizontal. Furthermore, you are cautioned in so augmenting the Stephen's prism that you make sure that the Risely prism is producing the proper effect; that is, base-up or base-down, according to which is needed, and before the proper eye.

There is one more useful test which is made on the phorometer. That is the determination of prism divergence. This is simply a measure of the amount of prism a person can take in the horizontal position without developing diplopia. In short, it is a measure of power or limit of divergence of the eyes which can be accomplished by any individual. For this test we purposely do not try to break fusion. The Risely prism is set at zero and placed before the *nonfixing* eye with the thumb screw turned to the vertical position. The examinee is told to look at the small muscle light with both eyes and to speak up when he is conscious of a break into two lights. The Risely prism is evenly, and fairly briskly, rotated to produce a base-in effect. When the candidate indicates a break, stop your rotation and read off the amount of prism power employed. Most candidates notice the break very suddenly, at which time the spread of the two images becomes so great that the examinee will request a retest. He will state he thinks he has missed informing you at the exact time at which the break actually occurred. Usually, however, this is an illusion, and the first reading is the correct one. More than two attempts to get a reading will cause fatigue and any subsequent reading without rest will be definitely false.

Why is such a finding of interest in a physical examination of aviators? Well, if a candi-

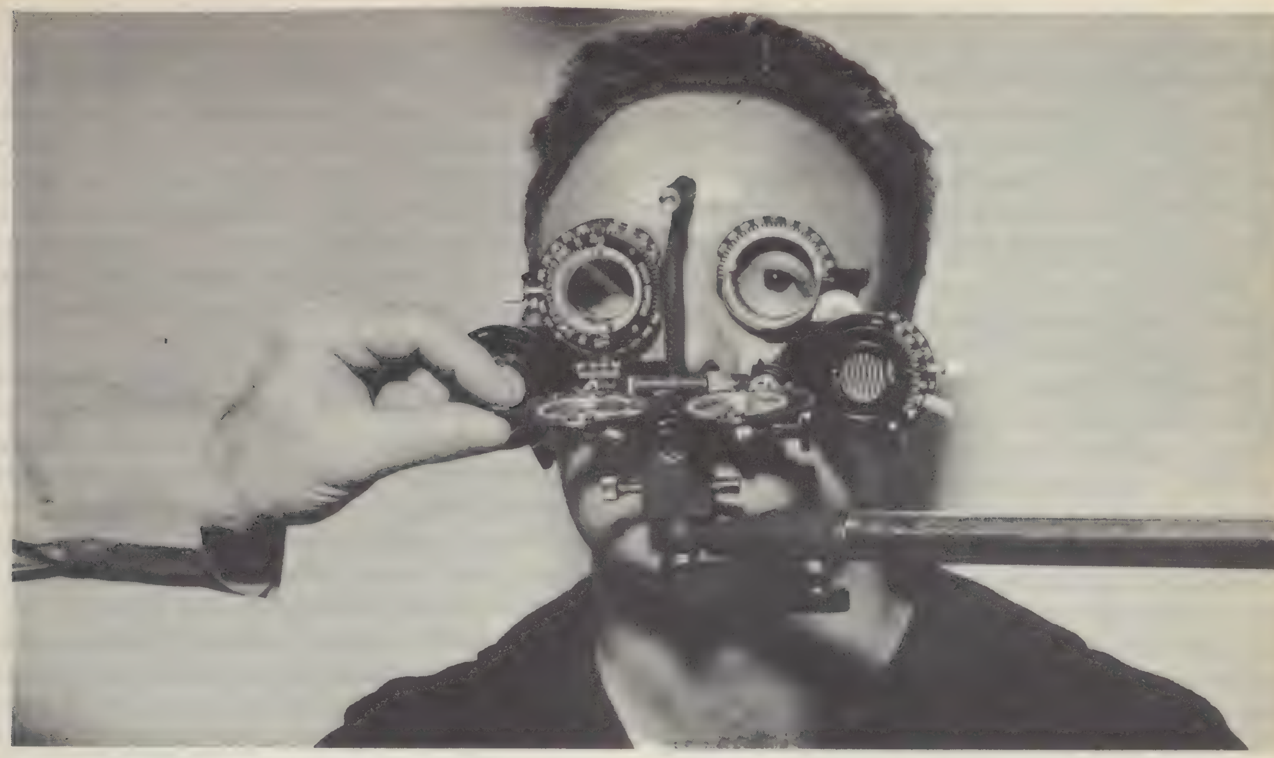


Figure 4-24.—Shows the Risely prism in position to augment the Stephens prism. Note the thumb screw of Risely prism is horizontal.

Figure 4-25.—Taking prism divergence. The Risely prism is producing base in effect which is being steadily increased.

date is found to have an esophoria it is assumed that the tendency to drift will be compensated without symptoms if that person possesses sufficient divergence power to offset this drift. We will discuss standards later but can say now that we require a person who has esophoria to be balanced by as much prism diopters of divergence power as he has esophoria.

Notice that up to now we have been discussing phorias and prism divergence on a distant target. At the present time serious consideration is being given to the need for running these tests at reading distance too. This thought is based on the fact that the modern aviator must read charts and instruments almost as much as he uses his eyes for distance vision. The examination of phoria for near, though not at present required, could be done by using the exact technique as described in the foregoing pages except that the target light, instead of being 20 feet away, would be the small light of an ophthalmoscope, with the head removed, and held at about 15 inches from the examinee's eyes.

COMMENTS ON PRESENT STANDARDS

The amount of phoria which a candidate may have in order to pass an examination for qualification for flight training was set by a board of prominent ophthalmologists during the first World War. They have stood the test of time. A recent research project[1] revealed the fact that of 250 aviators who came back alive from extensive combat missions in World War II (a good criterion for classifying them as successful) almost all of them were found to be within present standards. This indicates that our present standards are not too rigid. Some claim they are not rigid enough. The present standards and their applications may be explained as follows:

1. Esophoria: A candidate may have as much as 10 diopters of esophoria but if it is over 4 diopters he must be able to pass a "red lens test." Furthermore, any candidate who has esophoria must have prism divergence power of equal amount. That is, if he has an esophoria of 5 diopters he must have a prism divergence of 5 diopters or better. If the esophoria is under 4 diopters a red lens test is not required but the requirement for equal amounts of prism divergence still holds.

2. Exophoria: An exophoria of over 5 diopters disqualifies the candidate. Five diopters or less is acceptable.

3. Hyperphoria: Hyperphoria of more than one diopter disqualifies. Hyperphoria of one diopter or less is acceptable.

4. Prism Divergence: This power must be at least two diopters. Under two diopters disqualifies. However, if the power of divergence is greater than 15 diopters the candidate is also disqualified.

Prism convergence is not a part of the aviation physical examination. The angle of convergence is used in its place.

Angle of convergence (power of convergence or power of adduction).—The angle is computed from:

Near point of convergence (PcB)
Interpupillary distance (Pd)

The near point of convergence is represented by the symbol PcB (punctum convergens basalis), meaning the near point of convergence to the base line. This measurement is made from an imaginary line connecting the centers of rotation of the two eyes, situated 13.5 mm. behind the anterior surface of the cornea. The idea is to determine the greatest amount of convergence that can be exerted and still maintain binocular single vision.

Near point of convergence.—The end of the Prince rule, or a modification of same, is placed edge up at the side of the nose 11½ mm. in front of the anterior surface of the cornea. A white headed pin is held 33 cm. in the median line above the edge of the rule, and the examinee is instructed to look at it intently. If both eyes are seen to converge upon the pin, it is then carried in the median line along the edge of the rule, towards the root of the nose. The examinee's eyes are carefully watched, and the instant one is observed to swing outward the limit of convergence has been reached. The point on the rule opposite the pin is then read in millimeters. This test is repeated until a fairly constant reading is obtained. Usually the first or second try is correct and as the

[1] Imus, Henra A. "Visual Exam of Flyers Returned from Combat", BuMed Research Project X-395, *The Journal of Aviation Medicine*, April 1948.

trial is repeated the muscles become fatigued and the PcB gradually becomes more remote. To the reading thus obtained 25 mm. are added, (the center of rotation is 13.5 mm. behind the cornea and the end of the rule is placed 11.5 mm. in front of the cornea making a total of 25 mm.), which gives the distance from the near point of cenvergence to the base line. The normal eyes should be able to converge to 75 mm. or less. A near point more remote than 75 mm. indicates an under action of the internal recti.

Interpupillary distance. — The examiner stands with his back to the light, face to face with the examinee. The rule is laid across the examinee's nose in line with his pupils, as close to the two eyes as possible. The distance is measured from the nasal side of one pupil to the temporal side of the other. The examiner closes his right eye and instructs the examinee to fix his eyes upon his open left. With the eyes in this position a predetermined mark on the rule (preferably zero) is placed in line with the nasal border of the examinee's right pupil. The rule must be held steadily in this position while the examiner opens his right eye and closes his left. The examinee is then instructed to look at the open right eye. The point on the rule in line with temporal border of the examinee's left pupil is read in millimeters. The distance between the two points on the rule is the interpupillary distance.

The following formula is used to compute the angle of convergence: angle of convergence equals one-half the interpupillary distance multiplied by 100, divided by the near point of convergence, plus three, thus:

$$\frac{\frac{1}{2}\text{Pd.} \times 100}{\text{PcB}} \text{ plus } 3 = \text{Angle of convergence}$$

The above formula for determining the angle of convergence is purely empirical, and it is not accurate from a standpoint of pure mathematics. It is fairly accurate when PcB and Pd are approximately equal. It is suggested that the table showing the angles of convergence with different findings as to Pd and PcB be used instead, as this table is computed accurately from tables of tangents.

An angle of convergence of less than 40° is undesirable. If associated with exophoria in the upper limits, an agnle of convergence of less than 40° will call for a red lens test to be run. In short, we figure the angle of convergence in order to determine whether or not a red lens test must be done. For computation table see figure 4-27.

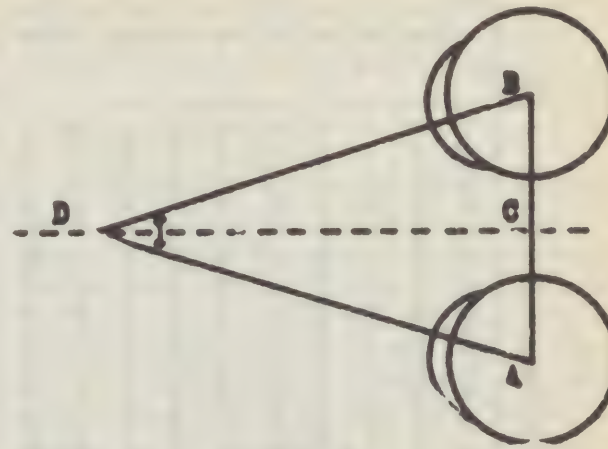


Figure 4-26.

These standards and others are recorded elsewhere in these notes in simpler terms which can be noted in a glance.

In addition to its use in an aviation physical examination, the phorometer is a valuable aid in physical diagnosis. The presence of a hyperphoria of over 1 diopter may explain the headache—the cause of which you have been searching elsewhere. The absence of any abnormal phoria eliminates that possibility of explaining a headache on that basis. Familiarity with the phorometer wll give accurate information in a few minutes. Lack of familiarity with its principles and markings can cause you to take an hour to get that same information.

Finally, for those who wish to check the eye glasses that a patient is wearing or to prescribe a change of lens, phorometer readings are of considerable importance in deciding upon the final prescription.

REVIEW QUESTIONS

1. Name three methods used to discourage the fusion center.
2. Which concept does an uncompensated exophoria produce—crossed, or homonomous?
3. A patient behind a phorometer with the Maddox rod before the right eye sees the line above the light. What kind of hyperphoria does he have—left, or right?

PoB	PD 55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
	ANGLE																				
40	69	69	71	72	73	74	75	76	76	77	78	79	80	81	82	82	83	84	85	86	86
41	68	69	70	71	71	72	73	74	75	76	77	78	78	79	80	81	82	83	83	84	85
42	66	67	68	69	70	71	72	73	74	75	75	76	77	78	79	80	80	81	82	83	84
43	65	66	67	68	69	70	71	72	73	73	74	75	76	77	78	78	79	80	81	81	82
44	64	65	66	67	68	69	69	70	71	72	73	74	75	75	76	77	78	79	79	80	81
45	63	64	65	66	66	67	68	69	70	71	72	72	73	74	75	76	76	77	78	79	80
46	62	63	64	64	65	66	67	68	69	70	70	71	72	73	74	74	75	76	77	78	78
47	61	62	62	63	64	65	66	67	68	68	69	70	71	72	73	73	74	75	76	76	77
48	60	60	61	62	63	64	65	66	67	67	68	69	70	71	71	72	73	74	74	75	76
49	59	59	60	61	62	63	64	65	65	66	67	68	69	70	70	71	72	73	73	74	75
50	58	58	59	60	61	62	63	64	64	65	66	67	68	68	69	70	71	72	72	73	74
51	57	58	58	59	60	61	62	63	63	64	65	66	67	67	68	69	70	70	71	72	73
52	56	56	57	58	59	60	61	62	62	63	64	65	66	66	67	68	69	69	70	71	72
53	55	56	56	57	58	59	60	61	61	62	63	64	65	65	66	67	68	68	69	70	71
54	54	55	56	56	57	58	59	60	60	61	62	63	64	64	65	66	67	67	68	69	70
55	53	54	55	56	56	57	58	59	60	60	61	62	63	63	64	65	66	66	67	68	69
56	52	53	54	55	56	56	57	58	59	59	60	61	62	62	63	64	65	65	66	67	68
57	51	52	53	54	55	56	56	57	58	59	59	60	61	62	62	63	64	64	65	66	67
58	51	52	52	53	54	55	56	56	57	58	58	59	60	61	61	62	63	64	64	65	66
59	50	51	52	52	53	54	55	55	56	57	58	58	59	60	61	61	62	63	63	64	65
60	49	50	51	52	52	53	54	55	55	56	57	58	58	59	60	60	61	62	63	63	64
61	48	49	50	51	52	52	53	54	55	55	56	57	58	58	59	60	60	61	62	62	63
62	48	49	49	50	51	52	52	53	54	54	55	56	57	57	58	59	60	60	61	62	63
63	47	48	49	49	50	51	52	52	53	54	54	55	56	57	57	58	59	59	60	61	62
64	46	47	48	49	49	50	51	52	52	53	54	54	55	56	57	57	58	59	59	60	61
65	46	47	47	48	49	50	50	51	52	52	53	54	55	56	56	57	57	58	59	59	60
66	45	46	47	47	48	49	50	50	51	52	52	53	54	55	55	56	56	57	58	59	59
67	45	45	46	47	47	48	49	50	50	51	52	52	53	54	54	55	56	57	57	58	58
68	44	45	45	46	47	48	48	49	50	50	51	52	52	53	54	54	55	56	56	57	58
69	43	44	45	46	46	47	48	48	49	50	50	51	52	52	53	54	54	55	56	56	57
70	43	44	44	45	46	46	47	48	48	49	50	50	51	52	52	53	54	54	55	56	56
71	42	43	44	44	45	46	46	47	48	49	49	50	50	51	52	52	53	54	54	55	56
72	42	42	43	44	45	45	46	47	47	48	49	49	50	50	51	52	52	53	54	54	55
73	41	42	43	43	44	45	45	46	47	47	48	49	49	50	51	51	52	52	53	54	54
74	41	41	42	43	43	44	45	45	46	47	47	48	49	49	50	51	51	52	52	53	54
75	40	41	42	42	43	44	44	45	46	46	47	48	48	49	49	50	51	51	52	52	53
76	40	40	41	42	42	43	44	44	45	46	46	47	48	48	49	49	50	51	51	52	53
77	39	40	41	41	42	43	43	44	44	45	46	46	47	48	48	49	49	50	51	51	52
78	39	39	40	41	41	42	43	43	44	45	45	46	46	47	48	48	49	50	50	51	51
79	38	39	40	40	41	42	42	43	43	44	45	45	46	47	47	48	48	49	50	50	51
80	38	39	39	40	40	41	42	42	43	44	44	45	45	46	47	47	48	48	49	50	50
81	37	38	39	39	40	41	41	42	42	43	44	44	45	46	46	47	47	48	48	49	50
82	37	38	38	39	40	40	41	41	42	43	43	44	44	45	46	46	47	47	48	48	49
83	37	37	38	38	39	40	40	41	42	42	43	43	44	44	45	46	46	47	47	48	49
84	36	37	37	38	39	39	40	40	41	42	42	43	44	44	45	45	46	46	47	48	48
85	36	36	37	38	38	39	39	40	41	41	42	42	43	44	44	45	45	46	46	47	48
86	35	36	37	37	38	38	39	40	40	41	41	42	43	43	44	44	45	45	46	47	47
87	35	36	36	37	37	38	39	39	40	40	41	42	42	43	43	44	44	45	45	46	47
88	35	35	36	36	37	38	38	39	39	40	41	41	42	42	43	43	44	44	45	46	46
89	34	35	36	36	37	37	38	38	39	40	40	41	41	42	42	43	43	44	44	45	46
90	34	35	35	36	36	37	37	38	39	39	40	40	41	41	42	42	43	44	44	45	45
91	34	34	35	35	36	36	37	38	38	39	39	40	40	41	41	42	43	43	44	44	45
92	33	34	34	35	36	36	37	37	38	38	39	39	40	40	41	42	42	43	43	44	44
93	33	33	34	35	35	36	36	37	37	38	38	39	40	40	41	41	42	42	43	43	44
94	33	33	34	34	35	35	36	36	37	38	38	39	39	40	40	41	41	42	42	43	43
95	32	33	33	34	34	35	36	36	37	37	38	38	39	39	40	40	41	41	42	42	43
96	32	32	33	34	34	35	35	36	36	37	37	38	38	39	40	40	41	41	42	42	43
97	31	32	33	33	34	34	35	35	36	36	37	38	38	39	39	40	40	41	41	42	42
98	31	32	32	33	33	34	34	35	36	36	37	37	38	38	39	39	40	40	41	41	42
99	31	32	32	33	33	34	34	35	35	36	36	37	37	38	38	39	39	40	40	41	41
100	31	31	32	32	33	33	34	34	35	35	36	36	37	37	38	38	39	40	40	41	41
101	30	31	32	32	33	33	34	34	35	35	36	36	37	37	38	38	39	39	40	40	41
102	30	31	31	32	32	33	33	34	34	35	35	36	36	37	37	38	38	39	39	40	40
103	30	30	31	31	32	32	33	34	34	35	35	35	36	37	37	38	38	39	39	40	40
104	30	30	31	31	32	32	33	33	34	34	35	35	36	36	37	37	38	38	39	39	40
105	29	30	30	31	31	32	32	33	33	34	34	35	35	36	36	37	37	38	38	39	39

Figure 4-27.—Table for computing angle for convergence.

4. How would you place a prism to correct esophoria—base-in? Base-out?

5. How would you place a prism before the left eye to correct left hyperphoria—base-up? Base-down?

6. What is the limit of hyperphoria for qualifications for flying?

7. What is the limit of esophoria?

8. If a person has 18 diopters of prism divergence, is he qualified?

9. If a person has esophoria 4 and prism divergence of 3, is he qualified?

10. Before which eye is the Maddox rod placed—fixing, or nonfixing?

11. Why is adequate prism divergence for near necessary to the modern flyer?

ASSOCIATED PARALLEL MOVEMENTS AND THE RED LENS TEST

An aviator during flight is constantly scanning the sky for approaching planes. Therefore, normal associated parallel movements are an important feature in his physical make-up. These movements are grossly checked during a physical examination by the simple confrontation test. The examiner faces the patient and watches the candidates eyes while a small test stimulus such as the eraser of a pencil is moved in the six cardinal directions of gaze.

1. To left in the horizontal.
2. To right in the horizontal.
3. Up and to the right.
4. Down and to the left.
5. Up and to the left.
6. Down and to the right.

If any overshooting or undershooting is noted the patient must be subjected to further testing of a more accurate nature. If, in checking the phorias, the examiner has found the candidate to have a phoria which approaches the upper limit for qualification, this same more accurate test for associated parallel movements is indicated. The confirmatory test chosen for this purpose is the so-called "red lens test."

In order to fully understand this test a brief discussion of the anatomy and physiology of the six extrinsic muscles of the eye is almost essential. The movements of the eyeball are termed as follows: upward rotation or elevation, downward rotation or depression, outward rotation, inward rotation and a twisting movement on the AP axis termed torsion. In torsion is defined as an inward rolling of the 12 o'clock position of the cornea. Ex-torsion is the opposite.

Let us consider the superior rectus muscle in detail. The origin of this muscle is the bone around the optic foramen. The muscle courses forward and outward to insert into the sclera of the ball about 7.5 mm. posterior to the corneal margin. It is obvious that the main function of this muscle is elevation. However, in an "eyes front" position the line of the muscle action crosses inside or nasal to the functional center of rotation of the ball. This fact accounts for the assignment, when the ball is in the "eyes front" position, of two auxiliary actions to this muscle, i.e., inward rotation and in-torsion. When the eye is, however, rotated outward, the functional center of rotation of the ball slips under the line of pull of this muscle. With a little thought you will appreciate that when the functional center of rotation of the ball is exactly in line with the origin and insertion of the muscle, the auxiliary actions of the superior rectus muscle are lost and it becomes solely an elevator. A little more thought will give justification to the statement that as an eye rotates outward the superior rectus muscle gradually loses its power of auxilliary action and gains in mechanical advantage to accomplish its *main* action. In other words the *field of action* of the superior rectus (the area where the muscle is exerting is *main* action at its best) is up and out.

In addition to the superior rectus muscle there is only one other elevator for the eyeball well forward in the lower portion of the boney—the inferior oblique. That muscle takes origin orbit at a point immediately lateral to the fossa of the lacrimal sac. It passes under the eyeball backward and outward to wrap partly around the ball, passing inside the functional center of rotation to insert in the sclera in the posterior upper-outer quadrant. The *main* action of this muscle is upward rotation or elevation. Like the superior rectus, and by the same line of reasoning as indicated for the superior rectus, the inferior oblique muscle has the auxil-

ACTION OF EXTRINSIC MUSCLES

Muscle	Main Action	Subsidiary Action	Field of Action
Superior Rectus	Elevation	Internal Rotation Intorsion	Up and Out
Inferior Oblique	Elevation	External Rotation Extorsion	Up and In
Inferior Rectus	Depression	Internal Rotation Extorsion	Down and Out
Superior Oblique	Depression	External Rotation Intorsion	Down and In
External Rectus	External Rotation	None	Out
Medial Rectus	Internal Rotation	None	In

Note that the external rectus and medial rectus have no auxiliary action.

liary actions of outward rotation and extorsion. As the eyeball is turned inward the auxiiiiary actions of the muscle fade in mechanical advantage until at a certain point the inferior oblique is solely an elevator of the eye. For this reason the *field* of *action* of the inferior oblique is *up* and *in.*

Similar analysis for the remainder of the extrinsic muscles will permit you to appreciate in your mind the facts presented in the accompanying chart.

The most useful fact to remember from a clinical point of view is the *field of action* of a muscle. It is often difficult for the student to appreciate that the resultant of the normal and auxilliary actions of a muscle is not the field of action. In a normal individual no eye movement is ever the result of the action of a single muscle. All six extrinsic muscles contribute to any movement of the normal eye. As one muscle contracts, other muscles called synergists help with the movements. At the same time antagonists relax proportionately. The result is a smooth and purposeful movement. There is no jerking and cessation of movement is accomplished sharply when the desired direction of gaze is reached. It is true, however, that in certain extreme directions of gaze one muscle carries the load more than others. It is sound deductive reasoning to assume that when an eye fails to follow in any particular direction of gaze, that muscle which is responsible for the field in which failure occurs is weak.

The basis for the explanation of the red lens test is the application of this deductive reasoning. The test will reveal:

1. Any failure to maintain associated parallel movements of the eyes.

2. What particular muscle is involved.

3. Is the involved muscle weak or is it overacting?

Since there are six extrinsic muscles for each eye, there are *six fields of action.* Test movements into these fields are called the six cardinal directions of gaze. If you stand behind your patient and imagine the movements of his eyes in the six cardinal directions you can readily diagram the muscles responsible for each field in this manner.

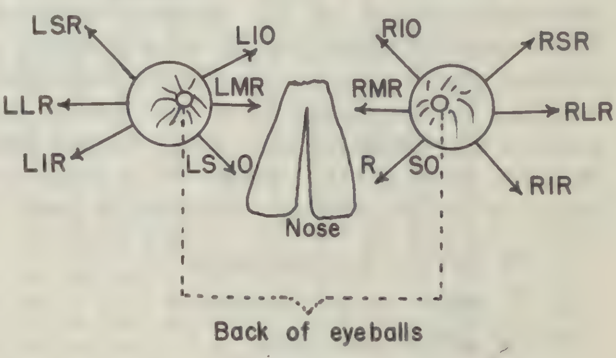


Figure 4-28.

Recalling the diagram from this aspect will be more useful. It may help in preparing this diagram if you will memorize the fact that the *fiield of action of the oblique muscles is always nasal.*

Technique of the test.—Any smooth surface such as a blackboard or tangent screen can be used. A chalk point or a white pin is used as a central point. The patient is seated 75 cm. from the surface and the right eye is covered by a red lens. This may be done by using a trial frame and a red lens from the trial lens box, or by improvising a red celluloid monocle to be held over the patient's right eye. The patient's head must be kept motionless. This is accomplished by improvising a head rest or by having an assistant hold the patient's head. A

Figure 4-29.—Candidate holding improvised red lens before his right eye. He holds his head motionless. Only his eyes move and try to follow the stimulus.

Figure 4-30.—Red Lens Test.—Paralysis of right external rectus. Diplopia increases as stimulus moves out into field of that muscle.

dimly lighted room makes the test easier. The tiny electric light of an ophtlalmoscope, with the head removed, acts as an excellent stimulus. The stimulus is held at the central point and the presence or absence of diplopia is noted. The normal person will see a single pink light. Diplopia in this primary position usually means a tropia exists but it may mean only phoria. The stimulus is moved slowly from the central point into one of the cardinal directions of gaze. The patient is asked to report immediately the presence of diplopia. When the stimulus has been moved 50 cm. from the center of fixation, without the occurrence of diplopia, the stimulus is brought back to the center and another field is explored. If diplopia does not occur in any cardinal direction within 50 cm. of the central point, the associated parallel movements of the eyes is considered normal and the patient is qualified.

If diplopia occurs inside the 50 cm. range, the operator, by a series of questions, locates the position of the red light and the position of the white light. The answers to this series of questions are often a challenge to the operator's patience and intelligence. (You can point to the false image in order to help the patient locate it. If you point to the true light stimulus the patient will see two pointers. If the image exactly over the location of the light is red the patient is fixing with his right eye and the second image is false. The location of the two images are marked and the movement of the stimulus is resumed to a point about 20 cm. further in that particular cardinal direction. Again the true and false images are located and marked.

The formation of a false image which increases in separation distance from the true image indicates abnormality in the eye which sees the false image. The field of action in which the diplopia increases indicates the muscles involved. Finally, if the diplopia is crossed the abnormal muscle is underacting (weak or paralyzed). If the diplopia is homonomous, the abnormal muscle is overacting. (This latter finding is infrequent.)

If you do not quite understand all this do not be too discouraged. It is not essential that the flight surgeon diagnose the particular muscle which causes the increasing diplopia, even though such information is of considerate clinical interest. The mere presence of diplopia occurring in any direction within 50 cm. of the central fixation point is disqualifying. In applying this standard, however, you are reminded that the patient must be exactly 75 cm. from the surface used for charting.

Diplopia, which first occurs beyond 50 cm. from the fixation point is not disqualifying. This extreme direction of gaze is never used normally. Furthermore, failure to maintain fusion in the extreme portions of the field is probably due to the normal effect of the check ligaments.

VISUAL FIELDS

Accurate studies of visual fields are time consuming. They have never been considered a part of a routine physical examination. However, many times after completing a thorough physical examination, you have unveiled information which calls for a visual field study.

For these same reasons, careful visual field studies are only made a part of the flight physical when other tests indicate the necessity of such study.

The instructions call for a confrontation test and grossly checking the visual fields of each eye. The examiner looks directly into the right eye of the examinee while he keeps his own right eye and the patient's left eye covered. While holding this gaze a test object is roughly moved through the entire visual field with the examiner using his own field as a control. If any discrepancy is noted on this test it is necessary to run a complete perimetric study. Any unusual appearance of the fundus upon examination would also call for perimetric studies—especially if the character of the lesion be doubtful. Whenever cupping of the disc is noted with the opthalmoscope or any increase in interocular pressure is suggested by palpation, visual field studies are always necessary for they may unveil sufficient findings to justify any early diagnosis of glaucoma.

As one would naturally expect, a person who has pathology sufficient to show up in a visual field tracing does not usually present himself

for flight training. Therefore, the test is seldom run in routine physical exams.

However, when a field tracing is needed it is usually needed badly. Not only flight surgeons but every doctor who has a perimeter available should be sufficiently acquainted with the technique of testing as to be able to perform the test without having to reach for a book of instructions.

Perimeters are built of various sizes. The eye of the patient must be placed at the distance from the fixation point for which the perimeter was designed. The most common sizes are 25 cm. arc. and 33 cm. arc. The patient's head must be securely fixed by the chin rest and the patient must be comfortably seated. The size of the stimulus is important. Often stimuli are found in clinics which are marked in degrees. The examiner must make sure that such stimuli are correct for the size instrument used. A ½-degree stimulus for a 33 cm. instrument would measure 3 mm.; such a stimulus would be ¾-degree for a perimeter of 25 cm. arc. Since a change in visual field is as important a diagnostic sign as the actual character of the constriction, the same size stimulus must be used for subsequent examination. Only then can repeated fields be compared.

A little patience in explaining to the patient what he is to do will save time in the end. The patient must be trained to keep his eye glued on the fixation point. The stimulus is brought from the unseen to the seen. Show the patient that in doing a tracing for white, or the so-called "form" field, the stimulus will first appear gray and then a definite white. The first appearance of definite white indicates the point to be recorded for any one meridian. Run through the vertical and horizontal meridians—then the four obliques. If these are all normal you may assume no gross constriction. If one of these appears to be constricted it might be well to run a few more meridia to either side of the constriction.

The size stimuli suggested in these notes are only intended as a guide. The smallest stimulus which brings out the largest field should be used. Once a size stimulus has been chosen a note to that effect must be made on the record. Don't forget to record the name and date. There is nothing more discouraging than getting two chartings mixed up so that both have to be done over.

For the interpretation of discrepancies in visual fields the reader is referred to complete texts on the subject. For the guidance of the flight surgeon any constriction of greater than 15° in any meridian disqualifies a candidate for flight training.

Beside studying the gross form of the visual fields as accomplished by perimetric studies, a further study must be made of the field which is functioning. For this purpose the tangent screen is a more practical clinical aid than the perimeter.

Tangent screens are prepared for these studies in two common sizes: a smaller one designed for a patient placed 50 cm. from the tangent screen and a larger type designed for 100 cm. working distance. One may construct a tangent screen of any size desired but the sizes mentioned are most commonly used.

Most tangent screens are constructed by stretching a black cloth over a supporting frame and marking out circles which represent various distances in degrees from the fixation point. These circles are nothing more than projections of the scale of the perimeter arc on a flat surface. It is obvious that the screen will accurately serve only for tracing defects in the central portion of the visual field; that is, defects within 30° of the center of fixation.

Working on a flat surface, the examiner may rapidly cover the central portion of the fields in search for scotomata. These are pathological anywhere except the physiological scotoma or blind spot. Any scotomata found are easily marked out by the use of common pins. The size of the blind spot is of considerable clinical interest. It is enlarged in many disease conditions such as glaucoma, papillitis, and papilledema. Any enlargement of the blind spot of more than 2° above average is considered as pathological. A ¼-degree stimulus is suggested for this type study. It gives more accurate tracings. In tracing out a scotomatous area it is well to remember that the stimulus should be passed from the unseen to the seen.

Existing standards permit the individual flight surgeon to decide what size *small* scotoma would disqualify the candidate for flying. However, a scotoma involving more than 15° of any meridian is automatically disqualifying. The decision on smaller scotomata would be made on the basis of etiology. Ordinarily no scotomata are expected, and the presence of scotomata always calls for assurance of the examiner that they are not due to a progressive disease. If there is any doubt on this score the patient should be disqualified. An old healed chorioretinitis, especially if it occurs in the nasal field might be disregarded if there are no other symptoms. It would be wise however to refer a person with a scotoma to an ophthalmologist for consultation before passing him.

We speak of fields of vision as temporal field, nasal field, upper field and lower field. One must keep constantly in mind that the temporal visual field represents a diagram of the function of the nasal retinal areas. The physiological blind spot which represents the entrance of the optic nerve into the eyeball is in the temporal visual field for it represents a part of the nasal retinal area.

The following notes are given to each student for reference during the lecture on this subject at the School of Aviation Medicine, Pensacola, Florida. They contain pertinent information.

USEFUL DATA FOR PERIMETER AND TANGENT CURTAIN

The perimeter—used for peripheral field study.

For White use ½° stimulus

For Blue
Red use 1° stimulus
Green

Formula for calculating stimuli where

S = Stimulus in millimeters
D = Stimulus in degrees
R = Distance of patient from the fixation point in mm.
$\Pi = 3.1416$

then

$$D = \frac{S \times 180}{\Pi R}$$

and

$$S = \frac{\Pi R D}{180}$$

The perimeter is usually used at 330 mm.
The tangent screen is usually used at 1000 mm.
Therefore use:

	33 cm. Perimeter	1 Meter Tangent Screen
Form	½° = 3 mm.	½° = 9 mm.
Color	1° = 6 mm.	1° = 18 mm.
Scotoma & Blind Spot	...	¼° = 4.5 mm.

With the following information you can make a tangent screen for any desired distance. The radius of each degree circle in millimeters is determined by multiplying the distance from the fixation point by the natural tangent.

Natural tangent	5°	= .0875
	10°	= .1763
	15°	= .2638
	15°	= .3640
	25°	= .5050
	30°	= .5774

To locate the blind spot:

From fixation point to proximal margin of blind spot	13.5°
Width of blind spot	5°
Height of blind spot	7°
Portion of blind spot above the horizontal	2°
Portion of blind spot below the horizontal	5°

Measurements of blind spot for 1-meter tangent screen:

From fixation point to proximal margin of blind spot	232 mm.
Width of blind spot	89 mm.
Height of blind spot	122 mm.
Portion of blind spot above the horizontal	33 mm.
Portion of blind spot below the horizontal	89 mm.

Normal limits of peripheral fields are:

White (form)		Blue	Red	Green
Upper	50........	30	25	15
Nasal	60........	35	25	20
Lower	70........	35	30	25
Temporal	90........	50	40	30

Pertinent signs to aid localization of pathology:

1. Disturbance of choroid—scotoma for blue.
2. Early axon or nerve fibre pathology—contraction of red.
3. Papillitis & papilledema—enlargement of blind spot.
4. Lesion in chiasm—hemianopsia.
5. Lesion in optic tracts—hemianopsia and quadrantanopsia.
6. Thrombosis or embolism in branch artery or vein—sector effect in one eye only.
7. Chronic pressure from glaucoma—contraction of nasal fields, enlargement of blind spot, Paracentral scotoma.
8. Hysteria—gun-barrel vision.
9. Any enlargement of blind spot of over 2° is cause for suspicion.

QUESTIONS FOR REVIEW

1. What size stimulus is usually used for form fields?
2. What size stimulus is usually used for color fields?
3. Why is the exact size of stimulus used and distance employed important for making reports?
4. Name two common causes for enlargement of the blind spot.
5. What is the criterion for assuming that a blind spot is enlarged?
6. What is the advantage of the tangent curtain in studying visual fields?
7. What are the limitations of tangent curtain studies?
8. What size stimulus would you use to trace the blind spot on a one-meter tangent curtain?
9. What is the limit of contraction of visual field allowed for aviation?
10. In which visual field does the physiological scotoma appear?

DEPTH PERCEPTION

Good depth perception is important for the successful performance of an aviator. It is important in making landings, in flying formations, in determining the distance of an approaching plane so that collision in air might be avoided. The distance and speed of approach of another plane are essential factors for the practice of accurate gunnery.

Many factors usually are combined before a final estimation of depth is accomplished. The stimuli which register in various parts of the nervous system are subconsciously combined and the distance of an object from the eyes is estimated in a flash.

For the purpose of study the various factors which combine to produce the estimation of depth can be classified as adjunctive and basic.

Adjunctive factors are those which depend upon a comparison or, better, the relation, of one outside object to another object outside the eye.

Basic factors are those which depend only upon the observer's perception apparatus and the object under estimation. These factors operate without dependence on other objects in the visual fields. Therefore, they are the only means of estimation of distance for a single ship on the horizon or a single plane in the air.

We would like first to explain briefly the various adjunctive factors. One example of an adjunctive is the comparison of the size of the retinal image of two objects. Based on experience, we know that a railroad car has a definite relation in size to that of another familiar object—a man. When a railroad car appears to be only as high as a man—the car is, of course, interpreted as being farther away than the man.

Another adjunctive factor is motion parallax. When you focus on a near object and move your head to one side, objects in your visual fields farther away than the object focused upon move with the movement of the head. Objects nearer than the object focused upon move against the movement of the head. Hold a finger from each hand before you and convince yourself by experiment.

Mathematical or linear perspective is another adjunctive factor. An example of this is the apparent meeting of the railroad tracks at a distance. We know they do not meet and, therefore, obtain a clue from the fact that they appear to meet. Aerial perspective helps us to judge distance. Our experience with various atmospheric conditions have taught us that for a given atmospheric condition, an object which

is surrounded partly by fog but still visible is a certain distance away. On a clear day the mountain tops appear to be surrounded by a blue haze. We know by experience that an object which is surrounded by haze on a clear day must be a great distance away.

You will note that all these adjunctive factors are available for persons having one eye. In fact, if we add the factor of accommodation to the four previously mentioned factors we have the total mechanism available for monocular depth perception. Accommodation contributes to the impression of depth by means of the steriognostic sense produced by ciliary contraction. It is, of course, only of aid when the object to be estimated is within 20 feet of the observer. For objects further away than 20 feet the amount of accommodation needed for focus is so small as to give practically no clue.

For monocular vision, therefore, we have the following factors available for the estimation of depth: (1) size of image, (2) motion parallax, (3) mathematical or linear perspective, (4) aerial image, (5) accommodation.

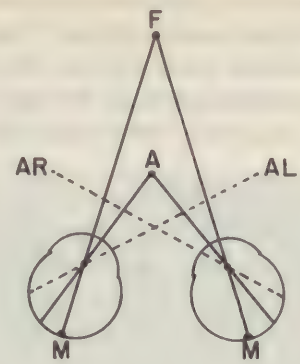
It was because of these factors that such persons as the famous Wiley Post and other aviators who have lost an eye are still able to fly. These factors do not accomplish very accurate depth perception. Their accuracy depends a great deal on the personal element—that is, the alertness of the individual—and also on his experience. The availability of these factors might permit experienced aviators who have lost an eye to fly but it would not be wise to allow a one-eyed person to start training.

The most accurate depth perception is accomplished by the factors available only with binocular vision. The man with binocular vision has all the adjunctive factors and accommodation available but he also has—

Physiological diplopia
Binocular parallax
Stereoscopic vision
Convergence

to help him in his final decision of the depth of an object in space.

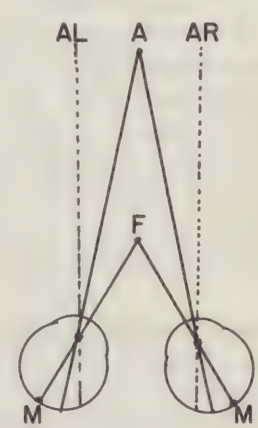
Physiological diplopia.—When a person focuses on a certain object the line of vision passes through the nodal point to the macula of each eye. If, while that person is fixed on the object, there appears in the field of vision



F = fixation point
A = second object in field
AR = projection of image of right eye } crossed diplopia
AL = projection of image of left eye
M = macula

Figure 4-31.

another object nearer than the object fixed upon, diplopia occurs due to the fact that the image of the nearer object falls to the temporal side of each macula. Since these areas are not corresponding, fusion cannot take place and a crossed diplopia occurs. The sensation of crossed diplopia, although suppressed from a point of view of attention, stimulates a cerebral level sensation of nearness of the second object in the field.



F = fixation point
A = second object in field
AR = projection of image of right eye } homonomous diplopia
AL = projection of image of left eye
M = macula

Figure 4-32.

The converse takes place for a more distant object looming into the visual field. The diplopia is homonomous and gives rise to the impression of greater distance than the object fixed upon. In this case the two nasal fields are stimulated.

Binocular parallax.—Binocular parallax has been accomplished when each of two objects in a field of vision stimulate exactly corresponding points in the retina. A little study of the following diagram will indicate that this situation can exist mathematically only when the two objects in the field fit certain conditions.

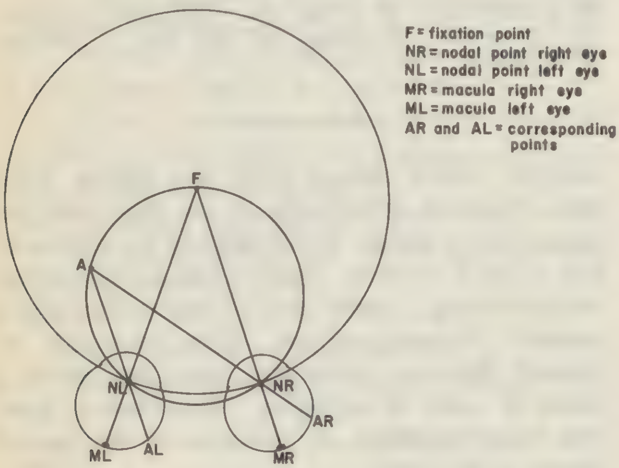


Figure 4-33.

The small circle passes through the nodal points of both eyes and also the point of fixation. Any circle which fulfills these specifications is called a Vieth-Meuller circle. A second or larger circle is drawn simply to indicate than an infinite number of Vieth-Meuller circles exist for any pair of eyes. Each time the eyes focus on a particular object a Vieth-Meuller circle is formed for that particular point of fixation.

Let us consider the eyes as converging on F. Each eye has point F, the nodal point and its macula in line.

Now point A is brought into the field. If point A happens to be on the Vieth-Meuller circle the angles indicated at the nodal point of each eye will be equal for they will both be subtended by the same arc—AF. It will follow therefore that, under those conditions, the arc MA_L will equal arc MA_R therefore, points A_R and A_L are mathematically corresponding points.

Note that line A-A_L and line FM_R are parallel in the diagram. They were made so purposely in order to help explain the principles upon which a well-known depth perception test is based. When point A is the same distance from point F as the person's interpupillary distance, the angle $A_L AA_R$ will equal angle $M_L FM_R$. This will give rise to the impression that A and F are the same distance from the eyes.

The term binocular parallax has been coined to describe this condition. But more broadly, binocular parallax exists whenever angle AN_RF for the right eye equals angle AN_LF. This can occur only when A is on the Vieth-Meuller circle for F.

If you can bear up under this dull reading for a little longer, we think the fog around this discussion will clear.

That part of the Vieth-Meuller circle which lies outside the eyes is called the horoptor. You will note that, mathematically speaking, as soon as A leaves the horoptor the angles at the nodal points of the eyes will no longer be equal and stimulation of corresponding points would be impossible. In fact it should be clear to you from previous discussion that physiological diplopia should, according to the diagram, occur as soon as A is moved off the horoptor.

It is obvious that as point F is moved out, or as the eye fixes on an object further and further away, the Vieth-Meuller circle becomes larger and the horoptor, therefore, flatter. Again from a mathematical standpoint when F, the point fixation, is at infinity the horoptor should be a straight line.

Our diagram permits all these mathematical facts to be stated quite readily. There is only one thing the matter—the visual system does not work that way. As a matter of fact, experiment has shown that physiologically speaking, as opposed to mathematical diagrams, the horoptor of the human eye becomes straight and flat at a distance of little over an arm's length. The functional corresponding units of the retina are not corresponding points but corresponding areas. As long as an object throws an image into each eye in such a manner as to stimulate corresponding areas no diplopia

occurs and the individual concerned develops the concept that the "off fixation" object causing that stimulation is the same distance from the eyes as is the point of fixation. When this physiological phenomena exists the eyes are said to be in binocular parallax.

The discrepancy between the mathematics of our diagram and the physiological facts might be further appreciated by the comment that the corresponding areas widen; that is, become less definite in the areas of the retina for off the macula. That is why we can get a much more accurate conception of depth for objects in the field of vision immediately around the object fixed upon.

This same widening of corresponding areas makes it necessary for us to make further adjustment of our mathematical principles to fit the areas immediately in front and behind the horoptor. We have already indicated that, mathematically speaking, as soon as an object falls forward or behind the horoptor physiological diplopia should occur. However, when we consider that the retinal units are corresponding *areas* and not corresponding points, it is easier to appreciate that there is an area in front and behind the sharp line of the horoptor in which objects do not produce the sensation of diplopia. That area too widens as we leave the point of fixation. This area is called *Panum's* fusion area and is diagramed as follows:

H – H' = Horoptor
Shaded area in Pannum's fusion area
Figure 4-34.

Objects which lie within Panum's fusion area give rise to the stereoscopic vision because they are fused. The sensation of the pull to maintain this fusion allows us to interpret this stereoscopic phenomena in terms of depth. By this we mean that fusion of an object just inside the forward or backward edge of Panum's fusion area will cause a sensation of pull to preserve fusion much greater than that necessary to preserve fusion when the object is directly on the horoptor. This sensation of depth which results from the "pull" of stereoscopic vision is very accurate for short distances. Beyond 2 meters stereoscopic vision rapidly loses its effectiveness as a cue to depth.

Figure 4-35.—The Howard-Dolman apparatus.

The Howard-Dolman apparatus is now used as a test for depth perception by both the Navy and the Air Force. The apparatus is designed to eliminate all cues of depth perception but physiological diplopia, binocular parallax, and sterocopic vision. The designers of the apparatus assumed that a person who could demonstrate proper use of these three faculties, which they called basic, could be considered safe to fly. They also assumed that failure to demonstrate proficiency in the use of these faculties must be considered as evidence that the person could not develop sufficient conception of depth to be termed safe for flying.

The Howard-Dolman apparatus consists of a fixed rod and a movable rod. The movable rod is placed on a slide which keeps it in a plane 64 mm. from the fixed rod. This distance was chosen because it is the average interpupillary distance of Americans.

If you look again at figure 4-35 you will note that the rod on the right (F) might be considered to be the fixed rod, while the rod on the left (A), the adjustable rod, may be moved by the examinee by manipulation of the strings. When (A) is a considerable distance in front or behind (F), the examinee receives depth cues by physiological diplopia. If the examinee has the ability to use binocular parallax he will stop the movement at such a point as to place the mov-

able rod exactly opposite the fixed rod. This is assuming that the examinee has an interpupillary distance of exactly 64 mm. For those who have a greater or smaller interpupillary distance, the binocular parallax cue is slightly less accurate. For this reason an allowance is made in the standard for passing this test. The candidate passes if the average of five trials gives less than 30 mm. separation between the fixed and movable rods.

Care must be taken not to permit the candidate to swing his head from side to side and thus get cues from motion parallax. He must not be allowed to swing strings from one extreme stop to the other. The candidate should be instructed to drop the strings out of his hand after each trial. Finally, the examiner must maintain a "poker face" lest the candidate get information from the examiner's expressions of approval or disapproval.

There has been much criticism of the Howard-Dolman apparatus in recent years. Research reports have been made which indicate that it has a low coefficient of reliability and validity. This discrepancy of the apparatus is now generally accepted but up to the present no other apparatus has been developed as a practical substitute. The criticism of the Howard-Dolman apparatus is based on reliable statistics which indicate that the apparatus does not show the same findings for the same man on retest. Furthermore, a series of tests run on successful college athletes, whom the tester claims must have had good depth perception, showed that a larger percentage of these athletes failed the test than occurs in a normal population.

Those who wish to defend the use of the apparatus feel that it still has clinical value. It is an easy test to perform and the test can be done by any well trained technician. Those who fail to attain an average of 30 mm. or less difference in 5 trials should at least be subjected to a more careful visual analysis before it is assumed that the apparatus is about to disqualify a normal candidate. In this man-

Figure 4-36.—Front and rear view of the Verhoff Depth perception.

ner the test acts as a screen for singling out persons who need a more careful physical check. If the test by its inaccuracy lets through persons with poor depth perception, that fact is regrettable. Obviously, surrendering the test would not change this situation. All these points must be considered by the Air Force and Navy committees on physical standards before a change in present directives are made. For the present we must use the Howard-Dolman apparatus as directed. Any flight surgeon who feels he is doing an injustice to a candidate, by failing him solely because of the Howard-Dolman test report, might well make a full report of the case and request that the Bureau of Medicine and Surgery give the case special attention and a final decision.

The Verhoff depth perception is now being studied as a possible replacement for the Howard-Dolman apparatus. It consists of a small box so arranged as to place before the examinee a series of variations of three upright rods. One of the three rods is always in front or behind the other two. The thickness of each rod is different in order to prevent the examinee from using the size of the image as a cue. The apparatus permits eight different relations of the rods to each other the test box is held at 1 meter from the examinee. All eight positions must be called correctly. Stereoscopic vision will be the examinee's only cue. If it can be proven that a person with good stereoscopic vision can be considered to have sufficient depth perception to safely fly an aeroplane, this apparatus may replace the Howard-Dolman apparatus.

REVIEW QUESTIONS

1. What is physiological diplopia?
2. Name three factors which contribute to depth perception of a one-eyed person.
3. What factors contributing to depth perception are only possible when binocular vision is enjoyed?
4. What is the Vieth-Mueller Circle?
5. What is the horoptor?
6. What is Panum's fusion area
7. Why is depth perception so important in aviation?
8. If you forget the effect of motion parallax how can you quickly remind yourself about it?
9. Name all the factors which aid in the estimation of depth.

COLOR VISION

When color vision of certain persons differs from that of the normal, these persons are said to be color blind. This is an unfortunate term for it implies that they are blind to all color and that all such persons have the same color perception. Neither of these implications has any basis in fact. The color-blind may be understood to include all those persons whose color vision is different from that of the normal and whose perception of color is, in general, more limited. They may be divided at once into two classes—the congenital and the acquired. We will not consider acquired color-blindness for this type is uncommon in the aviation age group; moreover, in these cases the defective color vision results from grave intoxication or is but part—usually a minor part—of a serious ocular or nurological disorder.

Congenital color-blindness is a developmental defect. It almost always affects both eyes. The other ocular functions are not affected. It is hereditary and tends to be transmitted through the females and to be manifest in the males. The condition cannot be corrected or even improved, though the color-blind do learn to conceal the defect. They are frequently ignorant of the defect themselves.

It is estimated that about 80 percent of the population have normal color vision. Of the remaining 20 percent, a considerable proportion are in the group who have acquired color-blindness. Congenital color-blindness of some degree occurs in from 8.5 to 10 percent of men and 2 percent of women. Color blindness of such as to be disqualifying in occupations requiring color discriminations occurs in approximately 3.5 percent of men and 0.7 percent of women. It is this 3.5 percent of the candidates for commission with whom we are concerned, but in examining applicants for flight training, effort must be made to eliminate the entire group (8.5 to 10 percent) with subnormal color perception.

Trichromatic or normal color vision is characterized by the following:

1. The spectrum of a glowing solid presents uninterrupted series of hues from red of about 760 to the violet of, say 380 μ.

2. There are no black, gray, or white areas or bands in this series.

3. In this spectrum the individual is able to recognize a large number of hues and clearly differentiates between the six or seven ordinary hues of red, orange, yellow, green, blue, indigo and violet. The ability to distinguish hues and colors is largely a matter of training; artists are superior in this respect and, as a rule, orientals also have a keener appreciation of colors.

4. Another characteristic feature of normal color vision is the fact that all colors with their almost infinite variety of hue, intensity, and saturation can be produced by the mixing in the proper proportions of three colors. These three spectral colors are red, green and blue and are known as the fundamental or primary colors. If we should take any two of these three colors and mix them in various proportions, certain colors which the normal individual is able to discern, cannot be produced as all three color wave lengths must be employed in order to produce all possible color sensations. For this reason normal color vision is known as trichromatic color vision.

There are two types of defective color perception with which we are concerned: dischromic and monochromic color perception. Both are disqualifying and the latter is much more difficult to detect. The dichromat sees only two of the fundamental colors and as for the trichomatic or normal individual, three are necessary to produce all hues in the spectrum. It is evident that the dichromat lacks power to be properly stimulated by one of these three. Now this may be red, green, or blue light. In conformity to this, we speak of red blindness, green blindness, and blue blindness; or in technical terms, protanopia, deuteranopia, and tritanopia, respectively. These are named in order of their frequency of occurrence. Tritanopia is very rare, and is usually caused by disease and detachment of the retina. It is believed that the dichromat spectrum has a neutral band of white or gray and the exact location of this band divides the dichromats into three groups, i.e.: protanopes (492 μ), deuteranopes (502 μ), tritanopes (570 μ).

There are many forms of color vision which connect the normal tricromatic with dichromatic vision. While these individuals recognize three fundamental colors, there exists a certain amount of difference between them and the true trichromats. This is generally referred to as anomalous trichromatic vision, or abnormal trichromatopia and is sometimes divided into protanomals and deuteranomals (partial or anomalous).

Stress is placed on detection of color blindness in prospective military aviators by reason of the requirements: (a) recognition of various luminous signals such as boundary lights, obstruction lights, navigating lights, and rocket signals. Distinctive colors are employed to signify various vital conditions and prompt comprehension is essential. (b) Recognition of colored flags and other daytime signaling devices. (c) Ability to discriminate between various conditions of terrain by colors thereof. For example: shades of green of pasture and short grass for a possible safe landing compared to a different shade of green in an adjacent area indicating a soft boggy marsh; shades of brown of a plowed field with soft, dangerous surface compared to a slightly different shade of brown indicating a field of dried grass or short, dry weeds which may prove to be a place to put the wheels down.

In a forced landing there is little time to make a choice and a second choice is impossible after altitude is lost. Rain, light fog, and a cloudy condition, especially in the early morning or toward evening, render color discrimination from an altitude very difficult for the normal eye and supremely hazardous for the individual with inadequate color discrimination and may easily end in disaster.

It has been found that individuals with defective color vision, even almost approaching normal, when excited or nervous frequently suffer reduction in color discrimination. A trichromat may be reduced to a dicromat and mistake a green light for a red one and vice versa.

Many theories have been and still are being formulated to explain trichromatism and the aberrations of the color blind, but so far, none have proven entirely satisfactory. Some of the more common theories are: Young-Helmhotz physical theory of three sets of nerves or cones; Hering psychological theory of three photochemical substances anterior to the cortex; and Ladd-Franklin theory on evolution

stating that the primitive man perceived only black and white.

The Ishihara test is very effective for color vision testing provided the examinee has not had an opportunity to study the plates. Many of them have done so. Hence, it is necessary for the examiner to have a degree of suspicion, especially in "re-examination" cases when using this test. Familiarity with the test is to be expected when (1) the plates with alternative readings are read with greater facility than are the plates with one reading, (2) greater difficulty is experienced in tracing the line plates than reading any of the plates, (3) there is any indication that the numerals do not stand out in bold relief as they do to the normal.

The advantages of the Ishihara over other tests are that it is rapid (1½ to 2 minutes) and will disclose practically all cases of significant abnormality of color preception and that it will never lead to a diagnosis of color blindness in a normal individual or in one who is not disqualified by regulations. Stillings pseudo-isochromatic plates are similar to the Ishihara. Because of the larger number of plates, it is more difficult for an individual with defective color vision to familiarize himself with them and, even if he has done so, the results of this study can be largely nulified by the simple expedient of turning the book upside down. If the plates are read in the same way with the same ease that the normal read them—record "normal." If there is any evidence that the plates do not afford normal contrast or, because of discrepancies previously referred to, it seems probably that the candidate has studied the plates, a detailed record is made of the readings and the examination is then continued with another test. The Edridge-Green lamp or the S6-690 lantern is frequently used as a secondary test and the results of which should be reported in addition to the plate readings when reporting a deficiency in color vision to BuMed. The lantern is done at 10 feet with 2 mm. aperture. Correct recognition of white, green, and red lights is required both when clear and when fogged. A new test lantern for colors has been developed by the Navy. It will probably replace the Edridge-Green lantern in the near future.

A summary of the Bureau of Medicine and Surgery "Color Perception Standards" and technique in using the pseudo-isochromatic plates which is given in mimeograph form to all classes of flight surgeons follows. For complete standards refer to BuMed *Manual*, par. 2125.

COLOR PERCEPTION STANDARDS

SUMMARY OF BUMED CIRCULAR LETTER 46-177

Device—American Optical Company Pseudo-isochromatic Plates

NOTE—DO NOT LEAVE THESE INSTRUCTIONS AROUND WHERE PROSPECTIVE CANDIDATES CAN MEMORIZE THE PLATES WHICH THE NAVY USES.

Technique.

1. Use Macbeth Lamp or equivalent.
2. Distance—Place plates 2½ feet from applicant's eyes.
3. Three seconds to read each plate.
4. Applicant told "Read the numbers."
   a. Show No. 25 (demonstration plate) first.
   b. Show the 18 "number" plates in any order you wish.
   Do not allow candidate to tilt, face or fuss into different angles of aspect.
5. "Line Tracing" Charts.
   a. First show demonstration plate No. 46.
   b. Have applicant trace No. 35 and No. 36.
   Do not allow candidate to touch plates with his fingers—have him use a glass rod or rubber eraser on a pencil. The use of fingers will soon stain and destroy the plates.

PLATES TO BE USED.

Plate No.	Normal Reading	Plate No.	Normal Reading	Plate No.	Normal Reading
6	6	12	97	36	follow
8	42	23	56	40	65
9	56	24	27	41	15
10	27	25*	12	42	74
12	57	27	89	43	47
14	75	29	86	44	98
19	5	35	follow	46*	follow
20	3				

* Demonstration Plates.

Standard	*Candidates for*
Must have 17 correct.......	Warrant Officers Commissioned Officers Nurse Naval Academy Naval Aviators Student Naval Aviators Enlisted men for special rates (such as signalman, electrician, etc.)

OPHTHALMOLOGICAL PROBLEMS OF AVIATION

Protecting eyes.—Until recently one of the greatest eye problems in aviation has been the selection of a goggle which would offer maximum vision and maximum protection. The goggle problem has faded out in view of the modern plane and its closed cockpit. We do not mean to insinuate that goggles are no longer needed in aviation but it is doubted whether they are important enough now to call forth any change in the very fine, one piece, sponge rubber framed goggle which was developed during the past war.

Sunshades of some form are still a definite necessity under some flight conditions. Anyone who has flown "on top" for any length of time is well aware that the glare from the white cloud masses will cause at least tiring and inefficiency if not permanent damage to the eye.

Aviators frequently ask the flights surgeon to advise them as to what is the best type sun glasses. Should they be brown, rose, green, or blue? Sun glasses are worn by aviators for several reasons. First, they protect the cornea from the heat of infra-red rays; secondly, they protect the conjunctiva and corneal epithelium from ultraviolet radiation which certainly causes temporary irritation; and finally, they suppress the tiring and annoying brightness of the background either in flying over clouds or over snow. One must avoid, of course, poorly polished glasses with astigmatic errors which will be disturbing and reduce visual acuity. Finally, we want, if possible, a glass which will not markedly intercept any particular color.

It is quite impossible for an individual to check these characteristics. Therefore, sunglasses should be bought from a reliable manufacturer who will guarantee that his particular glasses will keep out most of the infra-red and ultraviolet light. Furthermore, they should state that the lenses do not exclude more than 30 percent of any portion of the visual spectrum. Bausch and Lomb's "rayban" or American Optical Company's "kalobar" glasses will meet these specifications. They both have a greenish tint. If a manufacturer can make a blue tinted glass which will accomplish as good results, these too will be satisfactory. The color of the glass is not important.

If a pilot has any refractive error greater than ¼-diopter, it is most satisfactory to have his correction ground into his sunglasses. This can be done without too great expense.

When a pilot wears his sunglasses in the office, the wise flight surgeon will watch him closely. He may be hiding bloodshot eyes which are, in the absence of infection, an indication of unwisely spent nights. Anyone who claims photophalia under artificial light has either pathology or a very sensitive personality. In the latter case, it is well for the flight surgeon to take note of that fact.

When a pilot who is wearing sunglasses wishes to see better, he must take them off. This should always be done before landing on a smooth runway or smooth water. The best sunglasses will disturb perception.

Blackout.—The deficiancy in retinal function in relation to acceleration and deceleration is more properly discussed in the portion of the course dealing with aviation safety. The retina is the first nuerosensory mechanism to fail as the body is subjected to negative "G." The problem of avoiding these blackouts is more properly one of aviation physiology and aviation safety.

Anoxia.—Anoxia is another problem which is of considerable interest to the ophthalmologist in so far as visual efficiency decreases in every respect as the pilot passes into the early stages of anoxia. Resolving power diminishes and phorias increase, but the subject of the anoxia seldom recognizes his inadequacies. The treatment is not a problem for the opthalmologist

for it involves treating the anoxia or better—avoiding anoxia.

Night vision.—The ability to see at night is of supreme importance to the combat aviator. The retina, you will recall, has two types of neurosensory endings. They may be differentiated histologically by their shape. One type is long and narrow cystoplasmic formations called rods: the other type is relatively shorter and wider at the base and narrows down abruptly to a point. This shape has prompted the name—cone. Though these nerve endings are named according to their shape, they are most important because of their functions. The cones are concerned with photoptic vision or vision in adequate light. They are massed mostly in the area of the macula where there are no rods at all. As we pass off the macula area the rods appear abruptly and in great numbers but the cones become relatively few in number. Cones are scattered throughout the entire retinal areas but their relative number in comparison to rods diminishes rapidly as we pass toward the periphery of the retina. A very short exposure to daylight makes the rod endings insensitive to further stimulation. They remain insensitive until the eye is allowed to remain in the dark for a considerable period of time. No drug has so far been discovered, no food can be taken, which will cause rods to hold their sensitivity or restore their sensitivity, once lost. The only manner by which this can be accomplished is to keep the eye in the dark for a certain period of time. Physiological rejuvination of the rods is then accomplished.

At very low levels of illumination—levels much too low to permit stimulation of the cones of the retina—the sensitivity of the rods is retained. The resolving power of the rod endings of the retina is very low. For this reason, it is impossible for the human eye to attain the minute details in dim light which is possible under photoptic or bright light conditions. It is impossible to express in terms of candle power where the cones give up and the rods take over the visual stimulus. The effect is not an abrupt one but rather one of transition. From a practical point of view, we might state that any degree of light from the darkest blackness of a cloud-filled sky at night, through the starlight and the light of a dim moon to the light of a full moon on a clear night must be considered the light intensities through which the rods function. As we raise the intensity above the light of a bright moon the cones begin to come in and the rods begin to fail. The brighter the light, the more rapid the failure of the rod cells.

There appears to be little variance in the degree of sensitivity to scotopic conditions among healthy humans. You either have it or you don't have it. As has been said, no form of therapy will revive rod-cell vision to one who does not have it. As far we know there is no such thing as functional night blindness. People suffering from retinitis pigmentosa, lues, and other diseases lose their scotopic vision temporarily or permanently but we have heard of no true congenital night blindness. Physiological night blindness does occur whenever a person is exposed to any bright portion of the spectrum above the level of red.

With these facts in mind the problem of increasing a flyer's visual efficiency at night becomes one of training. This is started early in the career of an aviator and effort is made to teach student aviators:

1. How to preserve the sensitivity of their rod elements.
2. How to best employ the elements so preserved.

A special course of instruction is part of the syllabus of all Navy and Air Force student aviators.

The class is brought in from ordinary daylight to what appears to be a room of complete darkness. There is, however, at the time the students enter the room, a group of landscape silhouettes cast on the front wall of the lecture room by means of a very dim light.

While the students sit in through apparent complete darkness, the instructor explains roughly the physiology of the retina. He calls attention to the students that the macula which contains no rod elements is completely blind to dim light. As the students listen, the rod elements which were inactive when they entered the dark room, gradually regain their sensitivity. The instructor calls for any student who sees any object on the way to speak up.

The instructor now suggests that students will see more clearly in dim light if they will look,

not directly at the object of interest, but slightly off to the side. This, the students find, does work. They find that by scanning the simulated horizons before them that they pick up smaller and more difficult silhouettes with their off-center or peripheral vision.

Each student is now asked to close one eye tightly and cover it with his hand. The full lights are switched on for about one minute. The silhouettes disappear. The lights are switched off again and the student sees for himself that the eye which was covered is able to see the silhouettes as before but the eye exposed to the bright light is blind. Therefore, the flyer is advised that if he must use white light to read a map at night he must do so with one eye only, then at least one eye will remain dark-adapted.

The students now put on red goggles. The lights are switched on for a minute: they are told to keep their eyes open. Again the lights are switched off and the red goggles removed. The student finds by actual experience that a red light will not disturb his night vision.

The instructor now sums up the lesson. He advises student pilots that before they take-off at night they must dark-adapt their eyes by sitting in complete darkness for about 30 minutes. This period can be shortened to 10 minutes if red lenses have been worn for at least 20 minutes before entering complete darkness. Once dark-adapted, the flyer must not allow his eyes to be exposed to any but very dim light. If he must read it must be done in red light. Incidentally, he is advised not to try to read red print in a red light for he can't see it.

This vivid practical experience convinces the future pilot that there is a right way and wrong way to prepare for night flying. However, experience has proven that the flight surgeon should frequently "brief" his squadron on this subject to refresh their memories—especially when night flying is only infrequently performed.

BIBLIOGRAPHY

Title	*Author*	*Publisher*
Diseases of the Eye	May	Wm. Wood Baltimore, Md.
The Eye and Its Diseases	Berens	Saunders Company Philadelphia, Pa.
Textbook of Ophthalmology	Gifford	Saunders Company Philadelphia, Pa.
Introduction to Ophthalmology	Kronfeed	Chas. A. Thomas Baltimore, Md.
Methods of Refraction	Thorington	Blakiston Philadelphia, Pa.
Textbook of Ophthalmology (3 Volumes)	Duke Elder	C. V. Mosby Company St. Louis, Mo.
Outline of Ocular Refraction	Maxwell	Medical Pub. Company Medical Arts Building Omaha, Nebraska
Principles and Practice of Perimetry	Peter	Lea Febiger Philadelphia, Pa.
Anatomy of the Eye and Orbit	Wolff	Blakiston Philadelphia, Pa.
Extra Ocular Muscles	Peter	Lea Febiger Philadelphia, Pa.
Atlas Fundi Oculi	Wilmer	Macmillan Company New York, N. Y.
Internal Diseases of the Eye	Tronosco	F. A. Davis Philadelphia, Pa.
Surgery of the Eye	Wilmer & Alvis	Saunders Company Philadelphia, Pa.
Pectorial Survey of Military Optics	Business Letter Service	McGraw Hill Company New York City, N. Y.
The Human Eye in Anatomical Transparecies	McHugh, Gladys	Bausch & Lomb Press Rochester, N. Y.
The Ocularotary Muscles	Scobee, R. G.	The Cumosby Company St. Louis, Mo.

CHAPTER 5

OTOLARYNGOLOGY IN AVIATION MEDICINE *

Abnormal conditions of the ear, nose, and throat assume greater importance when dealing with flying personnel. A man working on the ground may be only slightly troubled with a moderate congestion of the nasal mucous membrane whereas an aviator at extreme altitudes could be incapacitated with a similar condition.

The following chapter is a brief discussion of otolaryngology, and is limited to the elementary principles as they pertain to the study of aviation medicine.

ANATOMY OF THE EAR

The external ear.—The external ear is that part of the auditory apparatus located laterally to the tympanic membrane. It consists of the auricle and the external auditory canal. The latter is divided into cartilagino-membranous and bony portions.

The auricle is an oblong, flat, molded structure consisting of skin covering a skeletal framework of elastic cartilage. The auricle differs in size and shape in different individuals but both ears usually are symmetrical. The landmarks include the helix, antihelix, tragus, antigragus, concha, lobule, incisura intertragica, auricular fossa, and the cavity of the concha leading to the meatus of the external auditory canal. The cartilage of the auricle is continuous with that of the canal except above and anteriorly where it is completed by a tough fibrous membrane extending between the tragus and the commencement of the helix.

Nerve supply.—The sensory nerves of the auricle are branches of the great auricular and lesser occipital nerves from the cervical plexus, and the auriculotemporal branch of the mandibular division of the fifth nerve. The posterior internal part of the external auditory canal is innervated by a branch of the vagus (Arnolds nerve). Stimulation of this auricular branch of the vagus is responsible for the cough reflex during instrumentation of the external auditory canal.

Blood supply.—The blood supply of the external ear is by twigs from the neighboring superficial temporal and posterior auricular arteries which are branches of the external carotid artery. The veins are branches of the facial and temporal and the posterior auricular veins. The latter sometimes join the transverse sinus through the mastoid emmissary vein.

Lymphatics and nodes.—The abundant lymphatic plexus of the auricle empties into the preauricular, post-auricular and inferior auricular lymph nodes. These in turn empty into the upper deep cervical nodes.

THE EXTERNAL AUDITORY CANAL

The external canal consists of cartilagino-membranous and bony parts. It is about 1¼ inches in length. The cartilaginous part forms about one-third of the entire length, its direction being upward and backward. The outer orifice of the canal is elliptical with its greatest diameter directed from the above downward. In its lower anterior wall are several fissures in the cartilage, the incisurae Santorini, which allow for flexibility of the canal.

The bony canal fuses laterally with the cartilaginous portion, forming two-thirds of the entire length of the canal. Its direction is downward, inward, and forward, forming an angle with the junction of the cartilaginous portion.

Histology.—The epidermal lining of the external canal is a continuation of the integu-

* Prepared by Cdr. D. G. MacKinnon, (MC) USN.

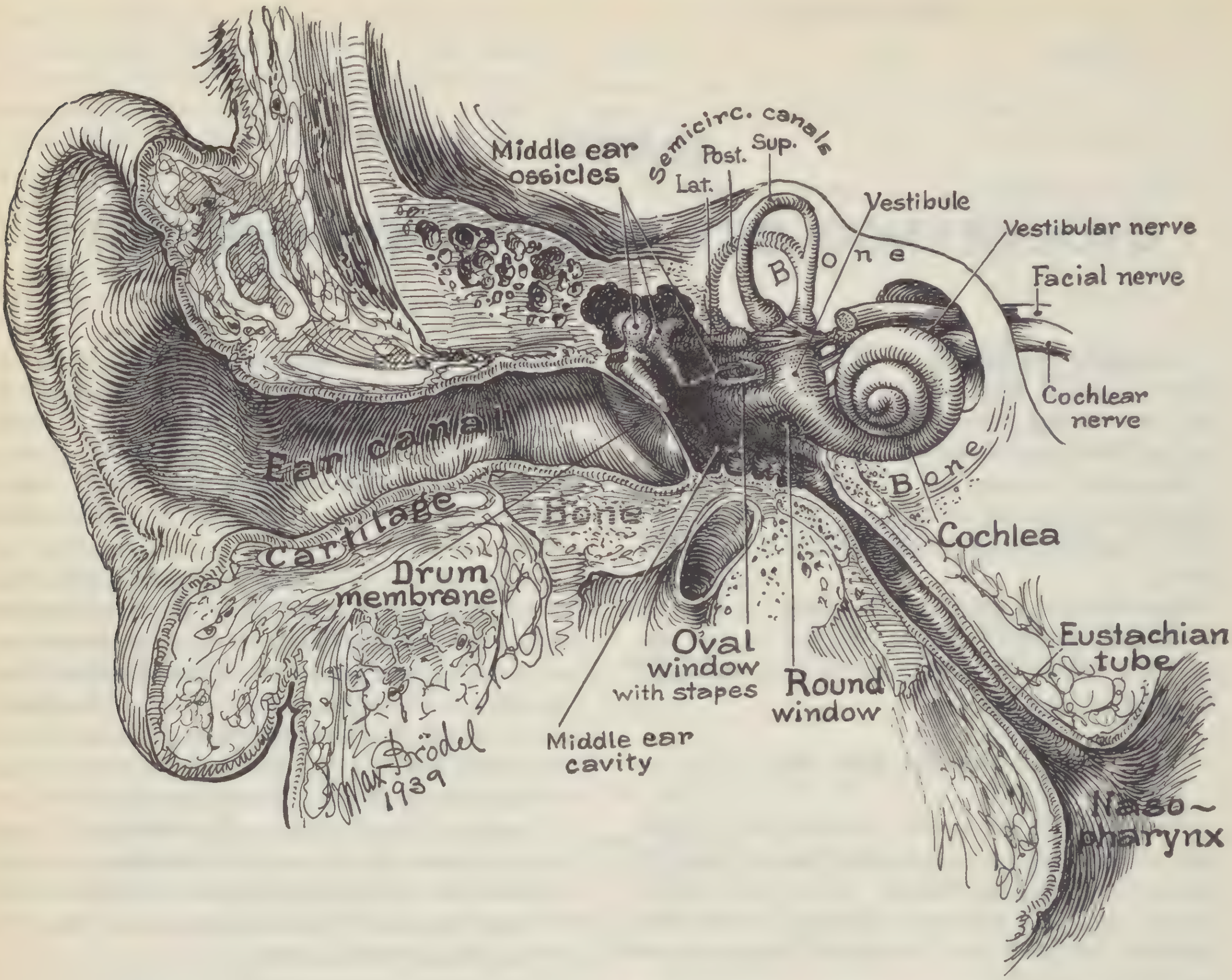


Figure 5-1.

ment of the auricle. The membranocartilaginous portion contains hair follicles, sebaceous and ceruminous glands. These are absent in the bony portion. The skin of the canal is tightly adherent to the periosteum, with almost no intervening connective tissue layer.

THE MIDDLE EAR

The middle ear contains the mechanism for the conduction of sound waves to the internal ear. It consists of a series of pneumatic spaces which include the Eustachian tube, the middle ear cavity itself and the pneumatic cells of the mastoid process. The cavity of the middle ear is best described as a six-sided box measuring 15 mm. from above downward and from front to back. Laterally, it is much narrower, measuring about 4 mm. from side to side near the top, even less than that near the center and then widening a bit near the bottom.

The lateral wall of the middle ear is partly bony and partly membranous. The membranous portion (the tympanic membrane) closes the middle ear cavity from the external auditory canal. The membrane is inserted in a groove in the tympanic bone by a circular ligament called the annulus tympanicus. The membrane is roughly circular, being about 8 mm. wide and 9 mm. high. It is about one-tenth of a millimeter in thickness and is made up of three layers. The outer layer or lateral layer is a continuation of the epidermal lining of the canal; the inner layer is a continuation of the mucous membrane lining the middle ear cavity. The middle layer consists of connective tissue fibers, both

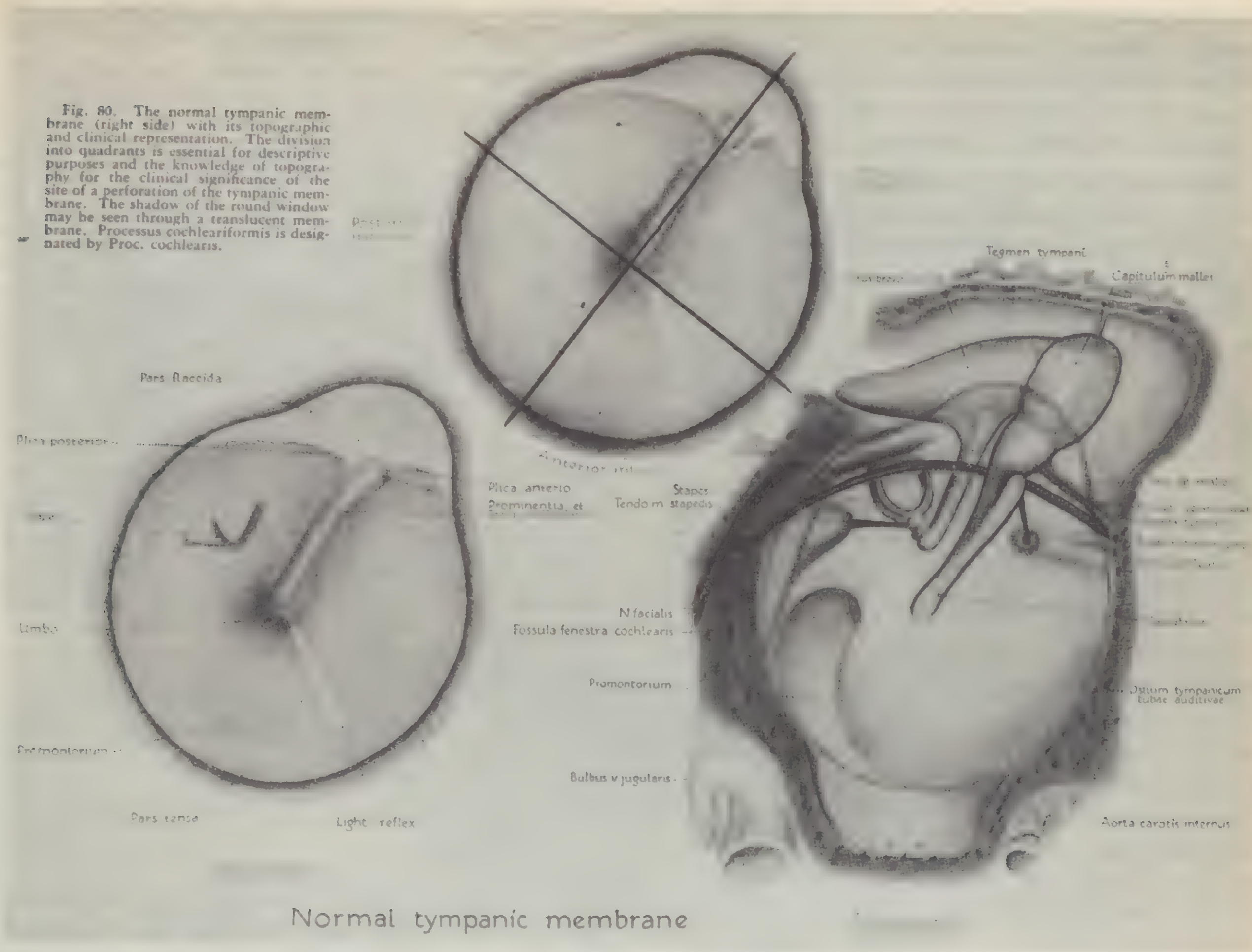


Figure 5-2.

circular and radial which are attached peripherically to the margins of the bony ring and centrally are inserted into the handle and short process of the malleus. This middle layer is relatively heavy (pars tensa) except for a small triangular area above the short process of the handle of the malleus, lying in a niche in the superior wall of the canal. This part of the tympanic membrane is called Shrapnell's membrane or the pars flaccida.

The lateral surface of the tympanic membrane.—The most depressed point of the tympanic membrane is located slightly posterior and inferior to its center. This corresponds to the tip of the handle of the malleus and is termed the umbo. From here a whitish streak, the handle of the malleus, extends upward and forward to the superior margin, to end in a slight projection, the short process of the handle of the malleus. From the short process two small ligaments extend to the edges of the notch of Rivinius, forming the anterior and posterior folds. These folds enclose that part of the tympanic membrane called Shrapnell's membrane. The cone of light is formed by reflection of concentrated rays of light from the surface of the membrane. It is normally found in the anterior, inferior quadrant, is triangular in shape with the apex of the narrow cone at the umbo.

The blood supply to the tympanic membrane is derived chiefly from the deep auricular branch of the internal maxillary artery. The blood vessels lie chiefly with nerve fibers in Shrapnell's membrane, along the posterior margin of the handle of the malleus and just on the margin of the pars tensa. The mucous surface is supplied by twigs from the internal maxillary and the posterior auricular arteries. The two sets of arteries, one on either side

of the membrane, connect through anastomoses. The nerve supply to the membrane is from the trigeminal, glossopharyngeal and vagus nerves. The areas supplied by each have not been accurately determined.

Superior wall.—The superior surface, or tegmen, or roof, varies in thickness from 3 or 4 mm. to that of thin paper. It separates the middle cranial fossa from the middle ear cavity. It is a favorable site for extension of middle ear infections and fractures.

Inferior wall.—The floor or hypotympanum is a thin, bony structure separating the hypotympanum from the jugular bulb. The bulb may mound into the middle ear cavity and there may be dehiscences in the bony covering. This possibility should be kept in mind whenever a myringotomy is being done, as serious hemorrhage may result.

Medial wall.—The medial or labyrinthine wall is also the lateral wall of the inner ear. It contains several important structures and niches including the horizontal semicircular canal, the facial canal, the oval window containing the footplate of the stapes, the promontory and the round window. Anterior to the horizontal portion of the facial canal is the process cochleariformis, a pulley-like structure about which the tendon of the tensor tympani muscle curves before inserting on the neck of the malleus.

The oval window, closed by the annular ligament and the footplate of the stapes, communicates with the perilymphatic space of the vestibule. Below it the round window lies in a deep depression. It is closed by a membrane which separates the middle ear cavity from the scala tympani of the first turn of the cochlea.

The promontory is a plate of bone which bulges into middle ear cavity. The first turn of the cochlea lies behind, or medial to the promontory. The facial nerve lies in a canal above the stapes and below the bulge of the horizontal semicircular canal.

The posterior wall.—The posterior wall of the middle ear cavity is a continuation of the posterior wall of the external canal. It contains the continuation of the facial canal near its floor. The canal continues downward to emerge at the stylomastoid foramen on the inferior surface of the mastoid bone. This part of the canal contains the descending portion of the facial nerve.

The facial nerve.—The facial nerve follows a tortuous path, receiving and sending off many branches in its course from the brain stem to its final distribution to the muscle of expression of the face. Grossly, the nerve blends with the pars intermedia (or glossopalatine nerve) while it is still in the internal auditory meatus. It enters the facial canal, coursing forward and laterally to the facial knee (first portion). The geniculate ganglion is located at this point. From here the nerve bends backward, above the oval window as far as the posterior wall of the middle ear cavity (second portion). From here the nerve bends sharply downward to emerge from the stylomastoid foramen. Branches of the facial nerve given off within the facial canal are:

1. The great superficial petrosal nerve.
2. A twig to the stapedius muscle.
3. The chorda tympani.
4. Anastomotic branch with the tympanic plexus.

The anterior wall.—The anterior or carotid wall of the middle ear contains the tympanic opening of the Eustachian tube, the bony canal of the internal carotid artery and the semicanal of the tensor tympani muscle. The Eustachian tube connects the tympanic cavity with the nasopharynx. It is about 37 mm. (1½ inches) long and its direction from the tympanum is forward, downward, and inward. In the adult the pharyngeal opening is 15 mm. lower than the tympanic end. The tube is about one third bony and two thirds cartilaginous, the narrowest part of the canal being at the junction of the two. It opens into the middle ear in the upper half of the anterior wall of the tympanum. The osseous portion of the canal is always open but the trumpet-shaped pharyngeal end is normally closed. It is open only during the act of yawning, or swallowing when the lower lip of the opening is pulled downward by the action of the levator and tensor palatini muscles. The tube is lined with ciliated epithelium continuous with the mucous membrane of the nasopharynx and the middle ear.

THE TYMPANIC CAVITY

The tympanic cavity contains the ossicular chain of the conduction system together with its muscles. The mucosa is more elevated at the mouth of the Eustachian tube and is ciliated in character. The muscles include the tensor tympani and the stapedius. These are attached to the neck of the malleus and the stapes respectively. They are antagonists which act as a damper to prevent excessive movement of the ossicular chain during excessive stimulation. The body of the tensor tympani muscle lies in a semicanal above the Eustachian tube. Its fibers arise from the bony walls of this canal. It is innervated by the third division of the trigeminal nerve through the otic ganglion.

The mastoid.—In the discussion of the posterior wall of the middle ear we failed to mention a very important opening, the mastoid antrum. This is the aperture through which the pneumatic cells of the mastoid bone communicate with the middle ear and with the Eustachian tube and nasopharynx. The mastoid process is formed by the union of processes of the squamous and petrous portions of the temporal bone. Pneumatization of the mastoid varies in different individuals but all the cells communicate with the antrum and all are lined with mucous membrane similar to that of the middle ear cavity.

THE INTERNAL EAR

The osseous internal ear.—The osseous internal ear or bony labyrinth consists of the bony semicircular canals, vestibule and cochlea. It lies within the petrous portion of the tem-

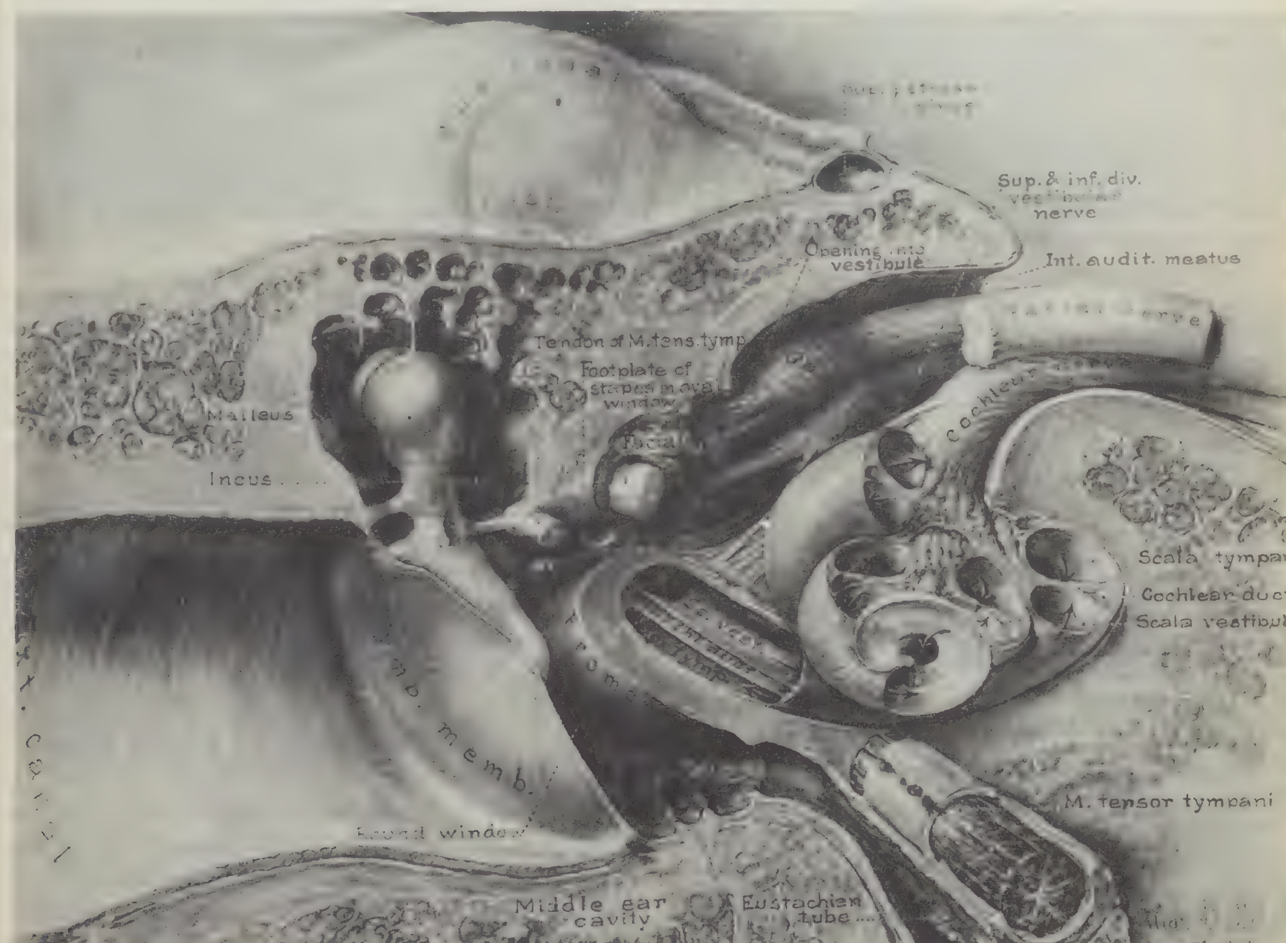


Figure 5-3.

poral bone. Laterally is the cavity of the middle ear, medially the internal auditory meatus. Through the latter it connects with the posterior cranial fossa. It consists of very dense bone 2 to 3 mm. thick, the bony labyrinthine capsule of the petrous bone. The bony inner ear has five openings externally: (1) oval window (closed by the stapes), (2) round window (closed by a membrane), (3) cochlear aqueduct, (4) vestibular aqueduct and (5) internal auditory meatus.

The capsule surrounds a system of cavities in which three parts may be distinguished: a middle part, the vestibule—an interior, the cochlea—and a posterior, the three semicircular canals. Within the cavity of the bony labyrinth is a membranous counterpart—the membranous labyrinth. This is surrounded by supporting fluid and anchored to the walls of the bony labyrinth by numerous small trabeculae. The supporting fluid is called perilymph. The membranous labyrinth itself is filled witth endolymph. The inner ear is separated from the middle ear by the oval and round windows. The oval window is closed by the footplate of the stapes and the round window by a membrane. Physiologically the labyrinth contains two entities, the acoustic apparatus, consisting of the cochlea and perhaps the saccule and the vestibular apparatus which consists of the three semicircular canals and the utricle.

The cochlea.—The bony cochlea is a short cone lying medial and slightly anterior to the middle ear cavity. The apex of the cone points anteriorly and laterally. It consists of two and a half turns about a central bony core, the modiolus. It is about 9 mm. in diameter and 5 mm. high. The membranous cochlea is divided into three sections by the basilar membrane and Reissner's membrane. The three divisions are the scala vestibuli which communicates with the oval window, the scala media which contains the organ of Corti, and the scala tympani which is separated from the middle ear by the round window membrane.

The scala vestibuli and the scala tympani which contain perilymph are connected by a small opening at the apex of the cone, the helicotrema. The scala media contains endolymph and is not in connection with the perilymph of the scala vestibuli or scala tympani. The organ of Corti, bathed in endolymph, is the sensory end organ for the reception and conversion of sound impulses and is connected with the cerebral centers by the auditory (VIIIth) nerve.

Vestibule.—The vestibule is a small cavity separated from the middle ear by the oval window. The vestibule contains two irregular saclike organs, the utricle and saccule. The utricle connects with the membranous semicircular canals and forms part of the vestibular apparatus. It also communicates through a narrow channel with the saccule which in turn joins indirectly with the scala media or ductus cochlearis. In the walls of both the utricle and the saccule rest delicate neuroepithelial organs called the maculae. The utricle is thought to function as an equilibratory organ. The function of the saccule is not known, although recent investigation indicates that it may have something to do with hearing.

Semicircular canals.—The bony walls of the semicircular canals are curved tubes, three in number, nearly semicircular, each of which is connected in two places with the wall of the vestibule. They are not all of equal length but are almost uniform in diameter (1.5 mm.) They lie in three planes almost perpendicular to each other, any two forming a right angle. The horizontal canal is the shortest of the three and is directed laterally and backward. Laterally and forward it adjoins the recess epitympanicus, and there produces the prominence of the horizontal canal in the floor of the antrum above the horizontal portion of the facial nerve.

The superior semicircular canal stands at right angles to the axis of the petrous portion of the temporal bone, making an angle of 45 degrees with the sagittal axis of the skull. It is close to the surface of the bone, giving rise to the prominence called the eminence arcuata. The posterior semicircular canal is the longest of the three. It lies almost parallel to the posterior surface of the petrous bone.

The membranous semicircular canals correspond in shape to the bony canals but with much smaller diameter. They join the utricle through the five openings in the walls of the vestibule. There are but five openings as the posterior and superior canals join and enter the utricle through a common opening. At one

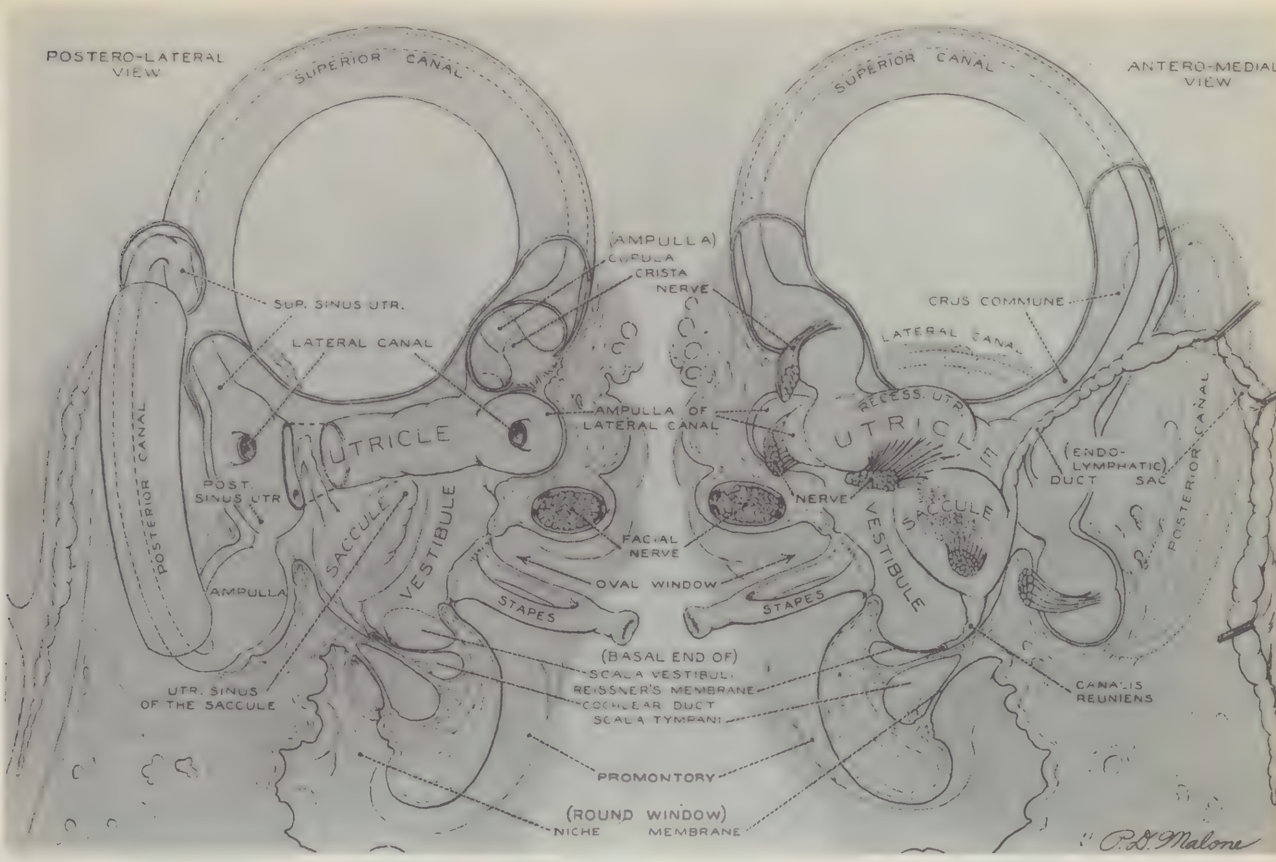


Figure 5-4.

of the extremities of each semicircular canal is an enlargement called the ampulla. Each ampulla contains specialized nerve and hair cells, comprising the crista ampullaris, the essential sensory receptor of that canal.

The structural arrangement of the semicircular canals is such that stimulation resulting from movement of the head may be perceived in any combination of planes—horizontal, frontal or sagittal. If we consider the anterior vertical (superior) semicircular canal as forming half of a circle, then the other half of the circle is formed by the posterior vertical canal of the other side. The horizontal canals of the two sides form two segments of a circle in the same plane. The ampullated ends of all canals lie anterior and lateral to the smaller end. The ampullae of parallel canals are functionally opposed to each other.

The utricle and saccule.—The semicircular canals comprise what is called the kinetic portion of the labyrinth. The utricle and saccule form the static portion. They lie in the cavity of the vestibule between the cochlea and the semicircular canals. They are small membranous sacs, the utricle being the larger of the two. The utricle receives the five openings of the membranous semicircular canals. It also has on one side an oval, thickened place of a whitish color, the macula acustica utriculi, in which terminate the fibers of the utricular nerve.

The saccule is a flattened spherical vessel (2 mm. in diameter) situated in front and below the utricle. It communicates directly with the scala media of the cochlea. On the medial surface there is a thickened area in which terminate the fibers of the saccular nerve. The saccule is connected with the utricle only indirectly through the endolymphatic duct. This duct ends in a blind cecal dilatation under the dura of the posterior surface of the petrous bone. The peripheral end organ of the vestibular apparatus consists of the crustae and

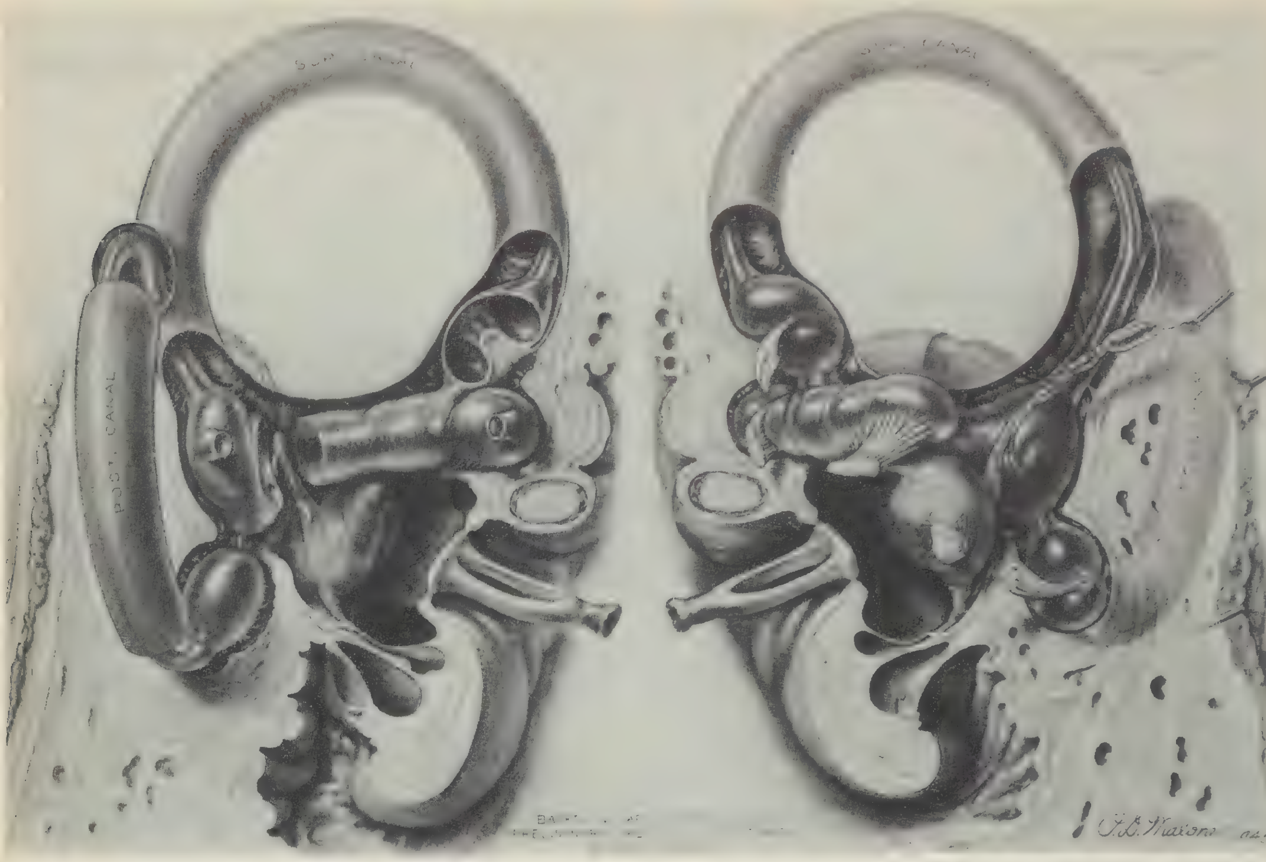


Figure 5-5.

maculae of the three semicircular canals, the utricle and the saccule.

The eighth or auditory nerve has a cochlear portion which transmits the auditory stimuli from the cochlea and a vestibular portion which transmits stimuli from the cristae ampullaris of the semicircular canals and the maculae of the utricle and saccule. The two portions of the nerve join and leave the temporal bone through the internal auditory meatus along with the facial (seventh) nerve. The cochlear and vestibular nuclei lie in the brain stem near the fourth ventricle.

PHYSIOLOGY OF THE EAR, NOSE AND THROAT

PHYSIOLOGY OF THE EAR

The external and middle ear.—The lobe of the external ear, the concha and the external canal serve to concentrate the sound waves and deliver them to the tympanic membrane. The handle of the malleus is incorporated in the membrane itself. By means of the three ossicles the sound waves are transmitted from the tympanic membrane to the footplate of the stapes in the oval window. In this manner vibrations are transmitted to the fluid of the cochlear chambers. Owing to the leverage arrangement of the ossicular chain the sound waves are transmitted to the cochlea decreased in amplitude but increased in intensity. The tensor tympani and the stapedius muscles are attached to the neck of the malleus and to the stapes respectively. These muscles are antagonists which contract in response to strong stimulation. By decreasing the amplitude of movement of the ossicular chain they produce a damping effect on the movements of the mechanism of the ear.

The middle ear is connected with the nasopharynx by the Eustachian tube. In this way atmospheric pressure is maintained in the middle

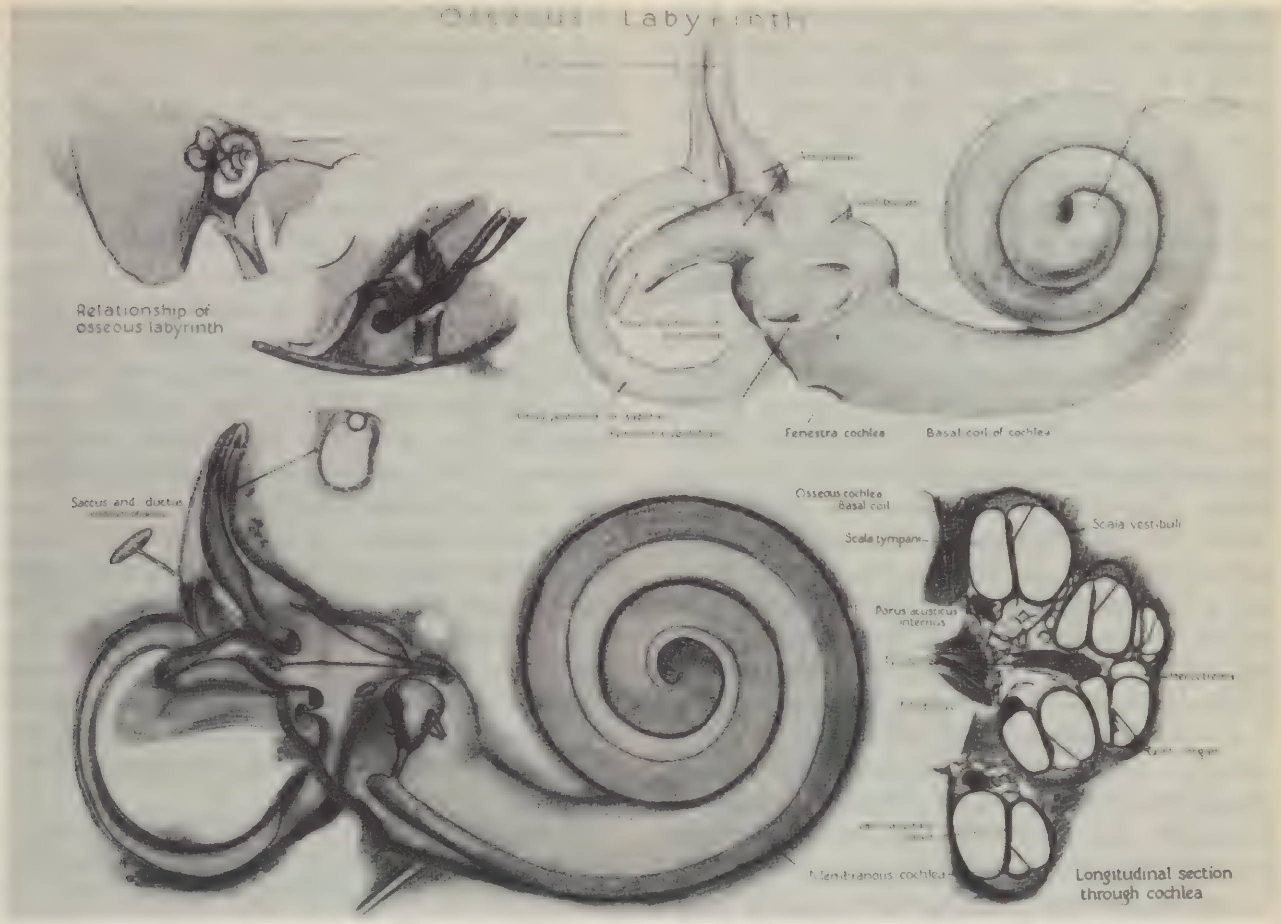


Figure 5-6.

ear and the pressure on either side of the tympanic membrane is equal. Disease of the nasopharynx which interferes with the patency of the Eustachian tube also interferes with the free movement of the tympanic membrane and the ossicular chain, causing deafness.

It has been shown experimentally that an intact drum is not essential for normal hearing. Any interference with the ossicular chain, however, is very likely to result in some hearing loss.

The internal ear.—The membranous internal ear consisting of the labyrinthine and cochlear portions occupies a small chamber in the temporal bone. The parts are bathed in common fluids, the perilymph without, the endolymph within, so that infection is readily carried from one part to the other. The blood supply of the internal ear is supplied mostly by the internal auditory artery, a branch of the basilar artery. It is an end artery with three branches. One branch supplies the cochlea, one the labyrinth and the third a portion of each. Occlusion of any of these branches results in immediate loss of function of that part of the internal ear which it supplies.

The nerves from the cochlea and the labyrinth have a common and united course into the medulla. In a clinical examination it is important to test both branches of the nerve. There are times when an indefinite hearing test may be established beyond all doubt by the result of the labyrinthine examination.

The cochlea.—From the footplate of the stapes the sound waves enter the cochlea. The membranous cochlea consists of a tube coiled on itself two and a half times around a relatively hollow core, the modiolus. This tube is enclosed in a dense bony covering which is coiled to resemble a shell. Hence, the name

cochlea. The perilymph is contained in two chambers or tubes, one above the cochlear duct called the scala vestibuli and one below the cochlear duct called the scala tympani. These tubes or chambers of perilymph join at the top of the cochlea, the helicotrema. The scala vestibuli begins at the footplate of the stapes in the oval window. It joins the scala tympani at the helicotrema. The scala tympani extends down from the helicotrema to end at the round window which is closed by a membrane. From the floor of the scala tympani a canal leads to the subarachnoid space in the cranial cavity near the jugular foramen. This canal, called the aqueductus cochlea, is filled with areolar tissue. Through it, there is a connection between the perilymph and the cerebro-spinal fluid.

A cross section from above down through the cochlea shows the modiolus in the center and the cochlear duct with its scalae at slightly different levels on either side. On examination of a cross section one sees coming off from the modiolus a bony shelf, the spiral lamina, to which the cochlear duct is attached internally. The outer side of the duct is anchored to the external wall by a ligamentous structure called the spiral ligament which follows it from the basal coil to the top. The cochlear duct is closed above by a thin loose membrane which is attached internally to the upper surface of the bony lamina and externally high up on the lateral bony wall. It is called Reissner's membrane. The floor of the duct, the basement membrane, extends from the spiral lamina to the spiral ligament. It is a firm tense band of laterally placed fibers and it is these fibers which are generally considered to be the vibrating or resonating elements of the cochlea. Resting on the basement membrane at its inner attachment is the actual nervous end-organ of hearing, the organ of Corti.

The organ of Corti consists simply of several rows of nervous hair cells which are held together by longer and firmer supporting cells which rest directly on the basement membrane. The tops of the hair cells project just above the level of the tops of the supporting cells of Deiter. Lateral to these are other types of supporting cells, including the fat-containing cells of Hensen. Over the point of attachment of the basement membrane to the bony lamina two of the supporting cells are modified to form rod-shaped structures called the rods of Corti. These rods are wide apart at their attachment to the basement membrane below; above they are in contact. By this arrangement a tunnel is formed which extends from the base to the apex of the cochlear duct. The hair cells are arranged in three rows external to Corti's rods and one row internal to Corti's rods. The nerves pass from the base of these cells into canals in the bony lamina, through which they enter the modiolus. There they join the spiral ganglion, then pass into the internal auditory meatus to form part of the eighth nerve along with the vestibular branches.

Just above the level of the hair cells of Corti's organ is the tectorial membrane. It is attached at its inner end to the upper surface of the spiral lamina. Its histology is still in doubt. Gray believes that it is a gelatinous membrane into which the hair cells of the organ of Corti project, as the gelatinous cupola overlies the cristae in the ampullae of the semicircular canals.

At the base of the cochlea the basement membrane is very narrow. It becomes progressively wider toward the apex until at the top coil the individual fibers are about three times as long as they are at the base. This fact is of importance as will be demonstrated when we discuss the theories of hearing, especially the resonance theory of Helmholtz.

The cochlear nerve.—The nerves from the cochlea and the labyrinth run together until they reach the medulla but from these they diverge widely. The cochlear nerve has reflex connections in the brain stem but it is mainly connected with the cortex of the temporal lobe of the same and opposite side. Recent experimental work indicates that the cochlea on one side sends an equal number of fibers to both temporal lobes—a symmetrical bilateral cortical representation.

After entering the medulla the cochlear fibers end about the cochlear nuclei which are in close relationship to the inferior cerebellar peduncles. From these nuclei some of the fibers run dorsally across the floor of the fourth ventricle to the lateral fillet of the opposite side. Others run ventrally as the trapezoid body to the lat-

eral fillet and ascend to the inferior corpora quadrigemina and medial geniculate body of the opposite side. Some fibers go to the lateral fillet of the same side; some to the nuclei of the nerves to the extraocular muscles. These latter are responsible for the associated movement of the eyes in response to sound. From the inferior quadrigeminal body and the medial geniculate body fibers pass to the auditory center in the cortex of the temporal lobe. Numerous decussations connect the various centers on the two sides. Because of the symmetrical bilateral representation of each cochlea in the brain it is rare to find deafness associated with any lesion in the brain situated above the level of the cochlear nuclei. Dr. Dandy has been able to remove the entire temporal lobe on one side without being able to detect an appreciable hearing loss. From this and a mass of other experimental data it follows that a lesion causing hearing loss is situated in or peripheral to the cochlear nuclei.

PHYSIOLOGY OF SOUND PERCEPTION

The cochlear apparatus.—This may be defined as a group of structures for the collection, transmission and registration of auditory stimuli.

The physical basis of hearing.—Two agencies are necessary for the production of sound. The first is a vibrating body such as a resonator, tuning fork, or vibrating string. The second requirement is an elastic medium by which the vibrations thus produced can be propagated some distance away to reach the ear of the observer. The medium most commonly used is air, but liquids, gases, and even solids can transmit sound.

The vibrations imparted to the air by a sound-producing mechanism are commonly spoken of as sound waves. The disturbance created consists of an alternating series of condensations and rarefactions propagated in a pendular manner in all directions. Sound, accordingly, is the sensation produced on the receiving apparatus by alternating rarefaction and condensation of air giving rise to sound waves. Two types of sound exist, viz., notes and noises.

Sound waves which form the units of hearing have certain attributes: loudness or intensity, pitch, and quality or timber. Frequency is the number of back-and-forth vibrations (double vibrations) of its particles in a given unit of time. The rate of vibration determines the pitch of a sound, high notes corresponding to waves which oscillate very rapidly, low tones to those of much lower speed. The range of hearing for the human ear lies between 12-and 28-thousand double vibrations per second. Amplitude is the distance traversed by a particle in its to-and-fro swing: graphically this is represented by the distance between the crest and trough of a wave. The third attribute of a sound is timber, a distinguishing quality apart from pitch or loudness characterizing sounds produced by different instruments, such as the piano, violin, or human voice.

Sound is practically always a combination of several frequencies and amplitudes. It is the function of the auditory mechanism not only to register these sound patterns but to interpret them in the light of past auditory experience, as musical notes, noises, or human speech components. A tone is sound produced by a number of equal and regular vibrations, while noises are vibrations which are irregular in length and time. Sound is a form of energy, the term being used by the physicist to designate the pressure waves that travel outward through air, fluid, or solid from any vibrating source. A sound may also be a mixture of many frequencies, as in a musical chord, or it may be an irregular mixture of waves of different wave lengths including a single spikes or transients. Such an irregular mixture is called a noise.

Speech is a composite of more or less pure tones and of noise, changing in composition and intensity from moment to moment. The intensity of the faintest sound that can be heard is known as its threshold. Naturally the threshold is not a constant unit but varies with the variations in individual auditory acuity.

Frequency of sound or pitch is measured in double vibrations per second. Intensity is measured in decibels. This unit is the minimal identifiable auditory increase at threshold level.

Perception of sound by the human ear covers the range from 16-to-22 thousand double vibrations per second. The useful range of the human voice lies between 256 and 2,048 d.v./sec. The behavior of certain animals indicates that

their ears are sensitive to vibrations as high as 40-or-50 thousand cycles.

THEORIES OF HEARING

There continues to be much discussion concerning the mechanism whereby mechanical vibrations of the air are analyzed and interpreted as sound. It centers around two main hypotheses; whether sound falling upon the ear is analyzed peripherally in the internal ear or centrally in the brain.

Central analysis.—The theory of central analysis is called the frequency or telephone theory. It presupposes that the sound is received in the cochlea from which nerve impulses of the same frequency as the stimulating sound are transferred to the nerve and are carried to the auditory centers in the brain where analysis takes place.

Peripheral analysis.—The theory of peripheral analysis is commonly called the resonance theory and is associated with the name of Helmholtz. It presumes that the cochlea consists of a series of resonating elements by which complex sound vibrations are broken up and analyzed into their simple constituent harmonic components so that the stimuli transmitted to the nerve fibers are simple nerve impulses from the different sections of the basement membrane. This latter theory is the more generally accepted.

The proponents of the resonance theory state that the transverse sectors of the basilar membrane when vibrating conform to the law of stretched strings. In order to respond to different sound frequencies the sectors must vary in tension, in length, and in mass or load. It is known that the fibers of the basilar membrane are three or four times as long at the apex of the coil as at the base. It is also an anatomical fact that the spiral ligament is much larger at the base of the cochlea than at the apex. This is interpreted as indicating that the short fibers near the base are under higher tension than the long fibers at the apex. Hallpike has shown that in the guinea pig the supporting cells of Hensen contain more fat at the apex of the cochlea than they do at the base. This causes a heavier fluid load or damping effect on the apical fibers.

In support of the resonance theory then we find that the short fibers of the basilar membrane are in the basilar coil of the cochlea where they are stimulated by high pitched sounds. It is computed that this variation in length alone will account for about one and one-half octaves of hearing. The thick heavy spiral ligament found in the basilar coil puts greater tension on the short fibers of the basilar coil than it does on the long fibers near the apex where the ligament is smaller. This variation in tension is computed to account for a range of hearing of seven octaves. The damping effect on the fibers near the apex is greater than at the base due to the increased amount of fat in the cells of Hensen in the apical coils. These three factors: variation in length of fiber, tension, and mass are calculated to account for a range of hearing of about 11 octaves, approximately that of the human ear.

Various other theories have been advanced but the majority of experimental work supports the idea of pitch localization on the basilar membrane. The mechanism as outlined above is undoubtedly an over-simplification of a very complex procedure, but present evidence seems to point to some form of pitch localization on the basilar membrane. While anatomical study and experimental research indicate the probability that sound is analyzed peripherally, it is still not a proven fact. Even if it is assumed with Helmholtz and his followers that a certain amount of sound analysis takes place in the cochlea, it is apparent that in man, at least, hearing is a cerebral function.

The external ear, the tympanic membrane, and the ossicles make up the conduction apparatus of the ear. The cochlea, the auditory nerve, its nuclei, and the complex cerebral connections of the auditory pathway make up the perceptive apparatus. Since this highly complex mechanism is concerned with the conduction and perception of sound, it follows that any condition causing interference with the conducting mechanism would result in a *conduction deafness.* Similarly a lesion in the perceptive mechanism would result in a *perception deafness.* Lesions in both the conduction and the perception systems result in a mixed type of deafness. In conductive type of deafness the hearing loss is most marked in the lower

tones. In the perceptive type of deafness, on the other hand, the high tones are lost first.

EXAMINATION OF THE EAR AND FUNCTIONAL TESTS

The external ear and typmanic membrane.—Inspection and palpation of the external ear, the canal, and surrounding structures is important. Palpation of the areas about the ear may reveal swelling of soft tissues over the mastoid process or enlarged and tender cervical lymphnodes. Pressure on the tragus or pulling the pinna upward may cause pain, indicating the presence of an external otitis. To visualize the external canal and the tympanic membrane it is necessary to have a good light the rays of which can be projected into the canal parallel to the line of vision.

Occasionally it is possible to visualize the canal and the tympanic membrane by pulling the pinna upward and the tragus slightly forward. More commonly it is necessary to introduce an ear speculum of appropriate size, depending on the size and shape of the canal. Usually it is not possible to see the entire tympanic membrane without tilting the speculum slightly from side to side.

Hearing tests.—There are two types of hearing tests; those carried out with the voice and those with instruments for producing certain standard tones within the human hearing range. The purpose of the tests is to determine the degree and type of any deafness. They are also useful in helping to diagnose certain diseases of the ear and to separate diseases of the sound conduction apparatus from those of the sound perception apparatus. The tests employed are:

1. Conversational and whispered voice.
2. Tuning forks.
3. Whistles or the monochord.
4. The audiometer.

Speech tests.—Tests with the voice include use of the ordinary speaking voice and the unaccentuated whisper. The patient stands at the end of a room or hall at least 20 feet in length, so constructed that extraneous sounds are excluded. The patient, with eyes closed, stands with the ear being tested toward the examiner, the other ear being occluded by the finger or a Barany noise maker. The noise apparatus is used to exclude sound of the test words or sentences from entering the ear which is not being tested. Test words or sentences are spoken by the examiner in an even, conversational tone, beginning at the greatest distance and approaching slowly until the subject is able to repeat them accurately. The whispered voice is also used, a whisper being lower in volume but higher in frequency than the spoken voice. In using the whisper test the examiner uses only the residual air, that in the lungs after a normal exhalation.

The tympanic membranes should always be examined during the clinical examination to test hearing. Occlusion of the external auditory canal by cerumen may result in conductive type of deafness. It is also to be remembered that otosclerosis and inner ear disease are the only types of deafness in which a normal tympanic membrane is usually present.

Tuning forks.—Instrumental tests are designed to furnish the means for diagnosing the type of hearing impairment as well as the extent of the damage. By the use of tuning forks we can ascertain whether a hearing loss is due to a lesion of the conduction apparatus or of the perceptive apparatus. To do this we test the bone conduction, the direction in which a fork placed on the vertex is lateralized, the relative length of time a fork is heard by air as compared with bone (over the mastoid process of the same ear), and the range of hearing as determined by the lowest and highest tone that can be heard.

When testing bone conduction a control is used, the examiner's own conduction or an objective control, in which the criterion is the average duration of time that a testing fork is heard by bone in a series of normal beings previously tested with the same fork.

The tuning forks in general use include:

$C = 64$ d.v.s. used for testing low tones.

$c = 128$ d.v.s. employed for the Weber test.

$c_1 = 256$ d.v.s. used for the Rinne test. $a_1 = 435$ d.v.s. is also used.

$c_4 = 2048$ d.v.s. for testing high tone limit.

These forks suffice for all practical purposes, the normal tonal range being amply represented. Some prefer the c_1 (256 d.v.s. fork, however, for the air and bone conduction deter-

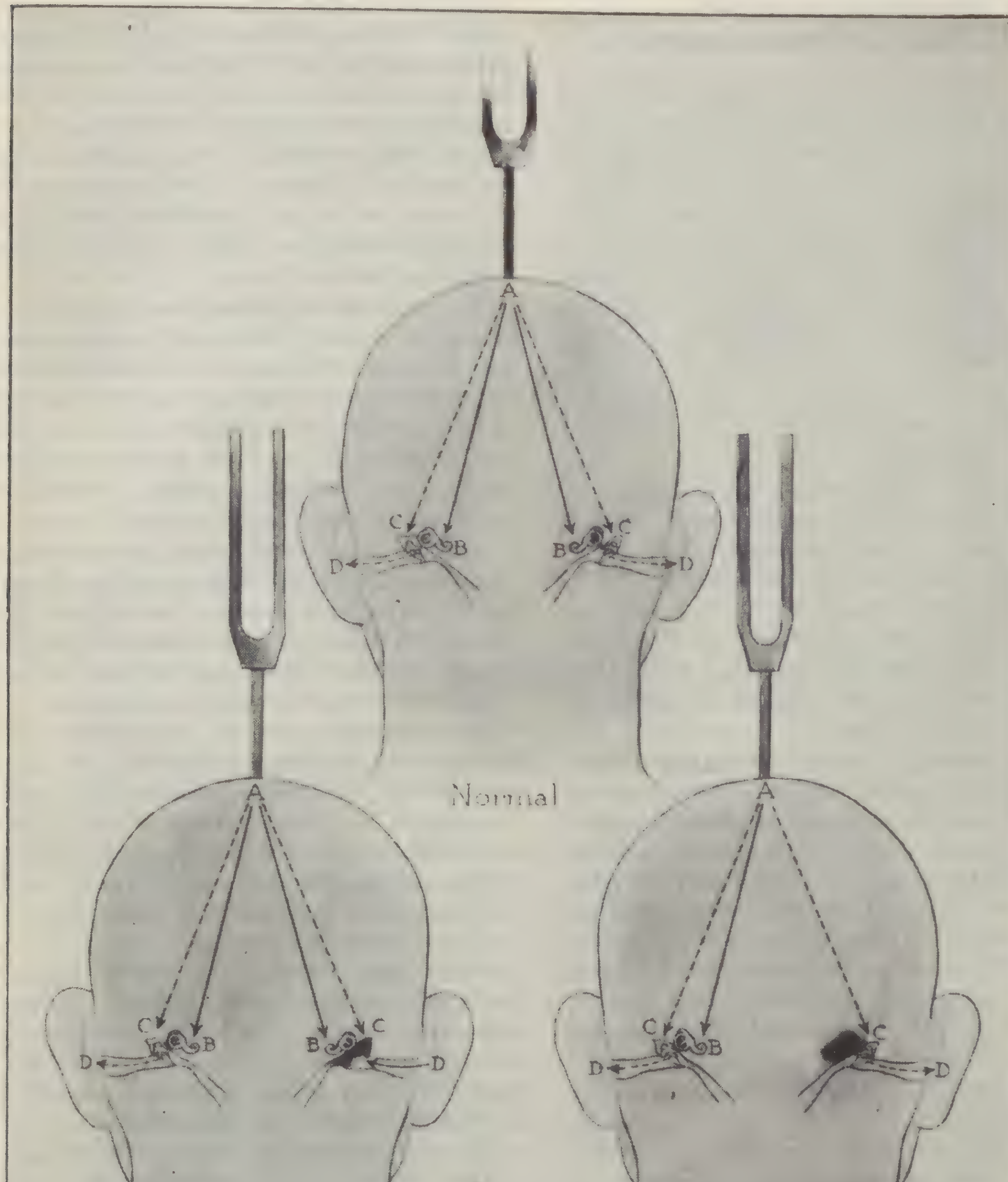


Figure 5-7.—Weber test.

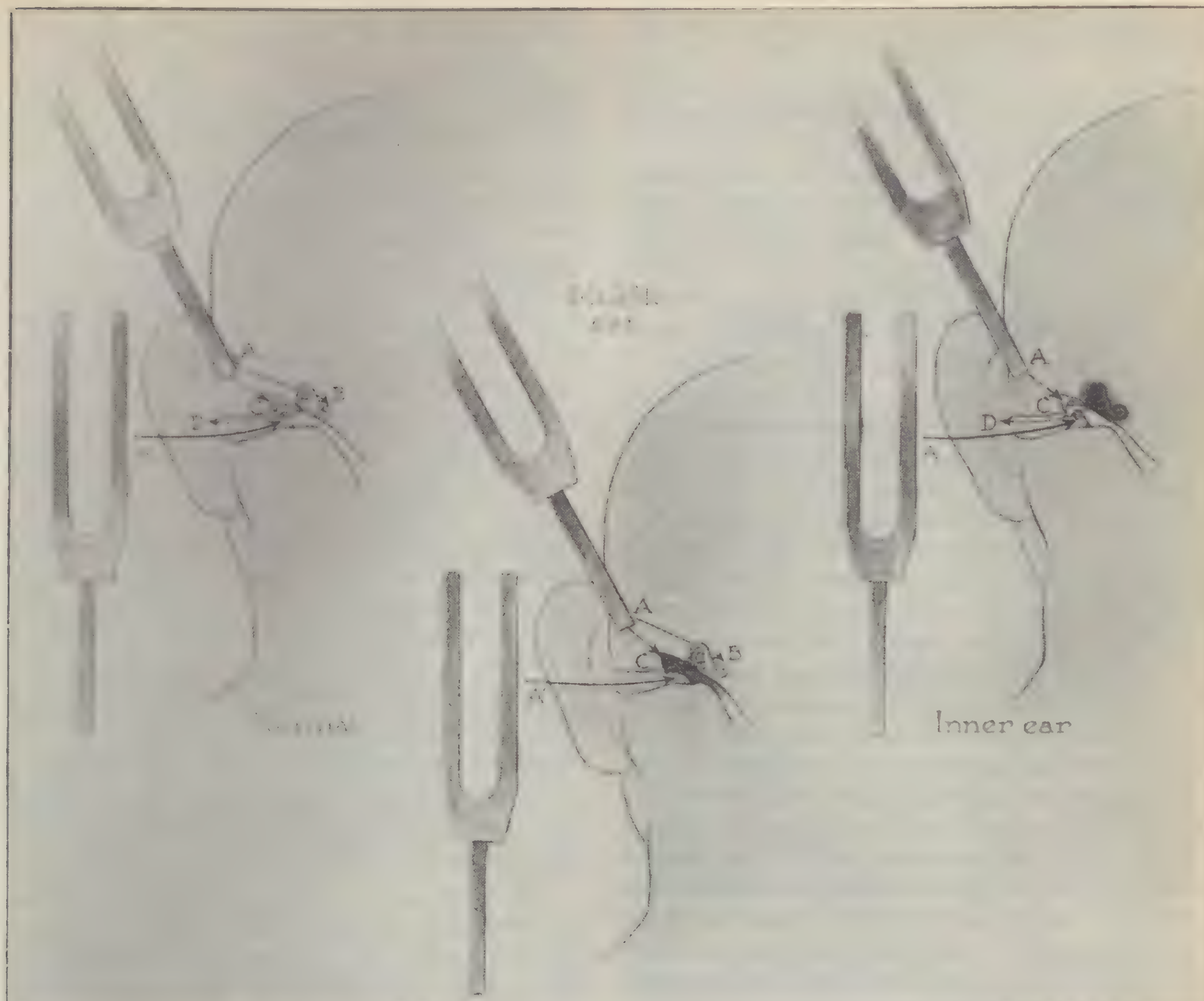


Figure 5-8.—Rinne test.

minations. Others prefer an a_1 fork (435 d.v.s) in the Rinne test and the unweighted A fork (108 d.v.s.) for the Weber and Schwabach tests. A national committee on hearing and tuning fork tests has recommended that only three standard tests be considered: namely, the Weber, the Schwabach, and the Rinne. The Weber and Schwabach are performed by placing the fork on the median line of the vertex or forehead, and for this purpose a fairly heavy fork resting largely by its own weight is desirable.

The Weber test.—This test determines whether the sound is perceived in the vertex (the patient says "heard in the head") or whether the tone of the fork is lateralized, that is, seems louder or entirely in one ear or the other. The result is recorded as "not lateralized" or "lateralized to the right or left" as the case may be.

With the tuning fork resting on the vertex of the head, part of the sound goes directly to the labyrinth through the skull. This is known as direct bone conduction. Another part of the sound goes through the skull to the tympanic cavity. This is known as indirect bone conduction. A part of this is reflected to the inner ear and part to the outside where it is lost. This happens normally on both sides but if one ear is closed the sound is heard much better on this side because the sound usually reflected to the outside is now reflected back toward the

inner ear. This is the case in lesions of the middle ear or external canal. In lesions of the inner ear the perception of direct bone conduction is interfered with so that sounds are heard best on the unaffected side.

The Rinne test.—This test is a comparison of bone (BC) and air (AC) conduction. Air conduction is normally longer than bone conduction. A medium pitched fork is placed on the mastoid until the patient states that he no longer hears it. It is then placed in front of the tragus until he can no longer hear it by air conduction either. When air conduction time is greater than bone conduction the Rinne is said to be positive. This is the normal condition. In middle ear disease the air conduction is impeded so that hearing by bone is greater than by air (negative Rinne). In inner ear disease bone conduction is impaired so that air conduction is increased over that of bone conduction. While this is also a positive Rinne the ratio is far greater than that of a normally positive Rinne.

Schwabach test.—In this test the fork is placed on the mastoid process back of the ear. The object is to compare the bone conduction of the subject with the normal. The fork is lifted from the head every few seconds and then replaced after a rest of a few seconds. This prevents fatigue of the nerve and gives a more reliable result. If the observer does not know the normal bone conduction time of his particular fork he may either use his own conduction time or that of any normal young adult. By this method it is possible to tell whether the subject's bone conduction is "normal," "shortened" or "very much shortened." In cases of middle ear disease bone conduction is increased, consequently the Schwabach is lengthened.

Having mentioned the lengthened Schwabach test associated with lesions of the conduction mechanism this will be a good time to speak of the mechanism of masking. As our environment is practically never completely quiet, our ears are constantly being bombarded by a multitude of extraneous sounds. In listening to conversation or music our ears are constantly having to strain out the sounds we wish to hear from the incidental noise about us. The more noisy the environment the louder will a person addressing us have to speak in order for us to hear distinctly what he is saying. In a case of middle ear disease external sounds are impeded by the lesion and air conduction will be reduced. Now, if we place a vibrating fork on the bony prominence behind such an ear bone conduction will be increased because the sound of the fork does not have to compete with extraneous noises coming in over the conduction apparatus. This masking effect is simply illustrated by placing a tuning fork on your own ear and then closing the ear with a finger. The sound of the fork will then appear louder and more prolonged.

Masking.—Masking is useful in attempting to establish a clear picture in monaural deafness. We may get erroneous answers while testing the bone conduction of a deaf ear because the sound is being heard in the other or normal ear. So it is frequently necessary to try to mask the good ear by means of one of the various types of noise makers now available.

Low and high limit tests.—The lowest note that the ear can hear may be tested by use of a fork with a frequency of 16 or 32 d.v.s. For high notes it is necessary to use a monochord or a Galton whistle. These devices produce tones of high frequency, the instrument being adjustable to produce a desired tone.

The audiometer.—The audiometer is an electrically controlled apparatus by which accurate measurements of hearing are obtained and charted in sensation units. The apparatus now in use is a vacuum tube oscillator which generates approximately pure tones over a wide range of frequency and intensity. It is essential that these instruments be standardized and calibrated properly. Audiometers are calibrated in decibels in frequencies from 64 to 8,192 double vibrations per second.

CLINICAL AND PHYSICAL APPLICATION

Taking 16 double vibrations per second as the lower tone limit and 28 thousand as the upper tone limit, the following variations may occur. In middle ear disease the low tone limit is raised in comparison with that of the normal person. The bone conduction is increased and therefore greater than air conduction (Rinne negative). In inner ear disease in the early stages all the tones can be heard except the

higher ones. Bone conduction is reduced, air conduction being greater than that by bone. The Rinne is positive. In combined forms of deafness the tone limit is narrowed from above and below.

In hysterical deafness all hearing is by air and absolutely none by bone. This gives an "infinitely positive Rinne." An infinitely negative Rinne is obtained in a case of unilateral deafness. There is no air conduction and the only bone conduction is that heard in the other ear which is really "borrowed" bone conduction.

A doctor is sometimes asked to determine whether or not an infant can hear. Certain reflexes are useful in this respect. (1) *Acoustical palpebral reflex.* The palpebral fissure will narrow after a sudden loud sound. (2) *Acoustical pupillary reflex.* Sudden loud noise causes contraction of the pupils. (3) *Acoustical muscular reflex.* Limbs will jerk at a sudden frightening noise. Any of these tests, if positive, prove the presence of hearing. Even if all three are negative it does not prove lack of hearing.

Malingering.—People feigning deafness rarely claim bilateral hearing loss. Usually they insist that they have total hearing loss on one side. Several tests have been devised to help detect the malingerer.

1. Weber Test. With fork on vertex and a finger in the good ear, he claims he hears poorly or not at all. A normal person hears better with ears occluded.

2. A person with normal hearing will raise his voice when speaking or reading in a noisy atmosphere. Place a Barany noise maker in the supposedly good ear of the suspect and ask him to read. If his hearing is good in the other ear he will not raise his voice.

3. Stenger Test. This is done with two forks of 435 d.v.s. If a fork is placed outside each ear the subject with normal hearing will hear only the closer fork. Place a fork close to the supposedly deaf ear, the other fork slightly farther away from the good ear. If he is really deaf he will hear only the sound in the good ear. If he is malingering he will hear only the fork close to the "bad ear" and will claim that he hears nothing. Put forks to both ears, allowing him to see the one before the good ear. Dampen this fork without his knowledge. He will still claim to hear the fork in his good ear.

4. By means of a special stethoscope arrangement have two observers talk into the patient's two ears. Hearing two voices at the same time the malingerer will be unable to prevent becoming confused and will trap himself.

DISEASES OF THE EXTERNAL EAR

Frostbite.—The ears of some persons are sensitive to extreme changes of temperature, the effects of which may vary from slight hyperemia to profound ischemia, terminating in local gangrene. At first hyperemic, the tissue soon becomes blanched, waxy, and vesiculated. The area undergoing such changes is demarcated, and if infection sets in, becomes ulcerated and even gangrenous. The best treatment is prophylactic, especially if the ears have already been frostbitten once. The circulation should be restored gradually by keeping the patient in a cool room. Cold compresses applied to the ear will prevent too sudden a return of circulation. Necrotic tissue must be removed, gangrenous areas allowed to separate spontaneously. After removal of nonvital tissue the denuded area should be touched with silver nitrate, 25 to 50 percent.

Hematoma.—The diagnosis is easy. Soon after trauma there is rapid effusion of blood between the cartilage and the perichondrium. A round, soft, bluish-red swelling forms quickly on the anterior surface of the auricle, obliterating the contour of the helix and antihelix. If seen early the contents of the hematoma may be aspirated. If late, it is often necessary to incise and express the clott. A snug dressing after evacuation of the clot will help prevent recurrence. The dressing should be maintained for 24 hours.

Acute perichondritis and abscess.—Acute perichondritis may be either a serious or suppurative exudation beneath the perichondrium of the ear. In addition to trauma, poor nutrition and certain infectious diseases have caused the serous type. The suppurative type, frequently with abscess formation, usually has a definite history of infection or trauma. Conservative treatment consists chiefly of supportive

measures. Dry or moist heat helps hasten absorption. It is sometimes helpful to aspirate the fluid from the collections under the perichondrium. A snug dressing over a mold of dental compound will help maintain the shape of the ear.

Sebaseous cysts.—Because of the necessity for wearing close fitting helmets and radio earphones by airmen, sebaceous cysts about the auricle should be mentioned. As elsewhere on the body the treatment of choice is complete extirpation of the sac.

DISEASES OF THE EXTERNAL AUDITORY CANAL

Foreign bodies.—These may be either animate, organic or inorganic. (*a*) Animate foreign bodies include a great variety of insects. Methods of removal vary from holding a light near the ear to spraying chloroform vapor into the canal. A simple method is to fill the canal with oil, after which the canal is syringed with warm water. (*b*) In removing other foreign bodies it is important to know whether or not they are hygroscopic. Those which will not absorb water may be washed out. If instrumentation is necessary the greatest care should be exercised to prevent injury to the thin and delicate skin of the bony portion of the canal. Even impacted cerumen can usually be removed by means of a forceful stream of water. The use of sterile water is indicated for many a doctor has washed cerumen from an external canal only to find a perforation in the tympanic membrane.

Furuncle of the external auditory canal.—These usually occur in the cartilaginous portion of the canal. The bony portion of the canal does not have hair follicles, sebaceous or sweat glands, the routes by which infection most commonly enters the skin. Pain is the outstanding symptom. As the skin is closely attached to the underlying cartilage there is little subcutaneous tissue present. A slight amount of swelling causes tenseness of the area with production of pain out of all proportion to the size of the lesion. Because of this the patients usually seek medical aid early. If the lesion is not obvious it may be located by touching different parts of the canal wall with a cotton-tipped applicator.

In the diagnosis of furunculosis it must be remembered that any disease which attacks skin elsewhere may involve the external auditory canal. In the majority of cases the differential diagnosis lies between otitis media and mastoiditis. With the advent of the antibiotics and the subsequent decrease in the number of cases of mastoiditis, even this is no longer literally true. Perhaps the cardinal point in furunculosis is the negligible reduction in hearing. In mastoiditis and otitis media there is marked hearing loss. In furunculosis tenderness over the mastoid is elicited on superficial pressure on the tragus, or lifting the auricle, while in mastoiditis the pain is deepseated. Roentgenograms are useful in determining bone pathology or cloudiness of the mastoid.

In treatment of furunculosis the first consideration is given to control of the pain. Warm moist compresses over the auricle, alternating with dry heat give the best results. After localization, incision of the abscess will hasten resolution. Loose packing of the canal with alcohol saturated strips of gauze is helpful. Or cresatin or phenol-glycerin (5 percent) may be used. In severe cases chemotherapy should be employed.

Otomycosis.—Of all the conditions which may involve the external ear canal perhaps the most common is otomycosis. This is especially true in temperate and tropical areas. Of the various fungi aspergillus is most frequently the causative organism. As a moist, warm environment favors the growth of the organism it is not surprising that it is so common in the external canal. Among swimmers it is of frequent occurrence, the maceration of the skin of the canal being a contributing factor. Treatment consists primarily of thorough cleaning and drying of the canal wall, vigorous wiping of the skin with alcohol and dusting the dry surface with some antiseptic powder such as sulfathiazole or boriciodine.

Injuries of the tympanic membrane.—This may follow direct trauma such as careless instrumentation or indirect violence such as occurs from a slap on the ear or entering the water incorrectly when diving. It is the primary finding in aero-otitis where the causative

factor is a difference in air pressure on the two sides of the tympanic membrane. The evidence of injury may vary from the slightest hyperemia to a ragged perforation of the tympanic membrane. In cases of head injury with fracture into the middle ear the possible complications and consequences are extremely serious. In most cases, however, the treatment consists of watchful waiting. It is not even advisable to attempt to clean the external canal, the possibility of introducing infection into the middle ear being greater than the danger of leaving it alone. Hemorrhages or exudates into the membrane are absorbed spontaneously. The great majority of lacerations will heal by scar tissue formation in a few weeks.

Aero-Otitis Media.—This is an acute or chronic traumatic inflammation caused by a pressure difference between the air in the middle ear and the surrounding atmosphere. It is characterized by pain, tinnitus, and occasionally vertigo. It is perhaps the most common otitic disorder among flying personnel today. In modern aircraft, and particularly in military aircraft, the body must compensate for rapid changes in atmospheric pressure. At 18,000 feet the atmospheric pressure is roughly half of that at sea level (760 mm. Hg). At 33,000 feet it is roughly one-fourth, or only 196 mm. Hg.

Present day planes are capable of ascending and descending several thousand feet per minute. It is essential that there be ready interchange of air between the middle ear and the external air in order to maintain equal pressure on the inside and outside of the tympanic membrane. A pressure differential of only 5 pounds is sufficient to rupture an eardrum.

Under normal conditions atmospheric pressure is maintained inside the middle ear cavity through the Eustachian tube. This is a narrow mucous-membrane lined tube leading from the anterior wall of the middle ear to the nasopharynx. The paryngeal end of the tube is slit-like in shape and the lumen is closed except during the acts of yawning, swallowing, chewing, etc., At such times the action of the levator and tensor palati and the salpingopharyngeus muscles exert tension on the lower lip of the opening of the Eustachian tube.

During ascent the air in the middle ear expands as the external pressure decreases. The excess air passes out through the Eustachian tube without difficulty: the individual may hear a snapping noise in the ear or feel a sensation as of bubbles moving through the tube.

When the atmospheric pressure is increased instead of decreased, a totally different effect is produced. The collapsed pharyngeal end of the Eustachian tube then acts as a flutter valve preventing entry of air. When the subject swallows, the lips of the tubal opening are pulled apart and air rushes into the middle ear, equalizing pressures within and without immediately. This is the usual mechanism by which pilots keep pressure on the two sides of the eardrum equalized during descent to lower altitudes. If, however, the pressure differential equals 80 mm. Hg. or more the Eustachian muscles can no longer open the tube. In such cases it is necessary to reduce the external pressure by climbing a few hundred feet.

During ascent there may be symptoms of fullness in the ear associated with tinnitus and occasionally pain. These are rarely severe as a pressure within the middle ear of 30 mm. Hg. or so is sufficient to force the air out the Eustachian tube with immediate relief. When letting down from higher to lower altitudes it is necessary for the individual frequently to open the tube and equalize the pressure by swallowing or yawning.

When a man is unable to equalize the pressure in his ears by conscious effort during descent there is a rapid onset of deafness, tinnitus, and pain in the ear. Vertigo may be present. At a negative pressure of 60 to 80 mm. Hg. the pain is severe. At a differential pressure of 100 to 500 mm. Hg. the membrane ruptures. When this occurs the patient suffers excruciating pain associated with a loud explosive noise in the ear; vertigo and nausea become marked and may be followed by shock and general collapse. Recovery is rapid but dull pain persists for a day or so and hearing loss for a longer period.

The findings on examination vary with the amount of pressure differential to which the ear his been subjected. In the less severe cases there may be only the signs of a retracted membrane. These include increased brilliance of the

light reflex and backward displacement of the handle of the malleus. Increased prominence will be found of the handle of the malleus and especially of the short process and the anterior and posterior folds. Shrapnell's membrane will be markedly retracted.

In more severe cases there may be hyperemia of the tympanic membrane with small hemorrhages into the membrane itself. The inflammation is most marked along the handle of the malleus and about the periphery. Depending upon the severity of the trauma and upon the length of time the condition has been present, varying amounts of serous or bloody fluid may be present in the middle ear cavity. If the tympanic membrane has ruptured there will be bloody fluid in the external auditory canal.

Aero-otitis chronic.—Chronic retraction of the membrana tympani is not uncommon. It is most frequently caused by lymphoid tissue in or about the pharyngeal orifice of the Eustachian tube. Less commonly it may be due to atresia of the canal or closure of the opening by scar tissue adhesions. The patients complain of stuffiness in the ears and are found to have a conductive type of hearing loss. These people almost always have difficulty in keeping the Eustachian tubes open when flying.

Treatment.—Perhaps the most important item is prophylactic. Careful examination to insure patency of the Eustachian canals before selection for flight training is essential. Men with chronic inflammatory diseases of the nose or paranasal sinuses should be screened out. In the field men with upper respiratory infections should be grounded until the flight surgeon is satisfied that the mucous membranes of the nose and throat have returned to normal. The vast majority of cases of aero-otitis occur among the lads who will not let a little head cold keep them on the deck.

Active treatment is confined to the nasopharynx and treatment of the underlying cause. The nose and nasopharynx are sprayed with one of the vasoconstrictors after which attempts should be made to inflate the middle ear.

Equalization of the pressure may be accomplished by the Valsalva maneuver, Politzerization or, when necessary, by means of the Eustachian catheter. Once the pressure in the middle ear is equalized the transudation of serum will cease and the structures will rapidly return to normal. The important thing is to keep the man on the ground until all signs of his upper respiratory infection have disappeared. The chronic cases are frequently relieved by radium treatment to the lypmhoid tissue about the Eustachian tube orifice. X-ray therapy is also used and in some cases may be preferable to radium.

Myringitis bullosa.—This is an inflammatory process confined to the outer layers of the drum and usually caused by infections of the canal or middle ear. It is characterized by the formation of vesicles in the drum membrane. It is commonly associated with influenza. If the middle ear is not involved the blebs subside spontaneously. Mild sedation and the instillation of auralgan into the external canal suffice to control the discomfort.

Otitis media.—In a chapter of this size such a comprehensive subject can only be touched upon. In 85 percent or more of such cases the condition is secondary to disease of the upper respiratory system. Perhaps congestion of the mucous membrane of the nasopharynx has caused obstruction of the orifices of the Eustachian tubes. Perhaps over zealous blowing of the nose has resulted in forcing infected material from the nasopharynx into the Eustachian tube itself. The sequence of events is roughly as follows: Obstruction of the Eustachian tube is followed by absorption of the air in the middle ear. The symptoms are stuffiness in the ear, loss of hearing (conductive type) and pain. If not treated at this stage transudation of fluid into the middle ear follows. If infection follows the middle ear cavity will fill with pus. If untreated the tympanic membrane commonly ruptures and pus drains into the external canal. Once drainage is established resolution may proceed rapidly. The sulfa compounds and penicillin have proven wonderfully efficacious in treating diseases of the middle ear. The serious complications of mastoiditis, sinus thrombosis, and brain abscess, so common before the advent of these drugs, are now rarely seen.

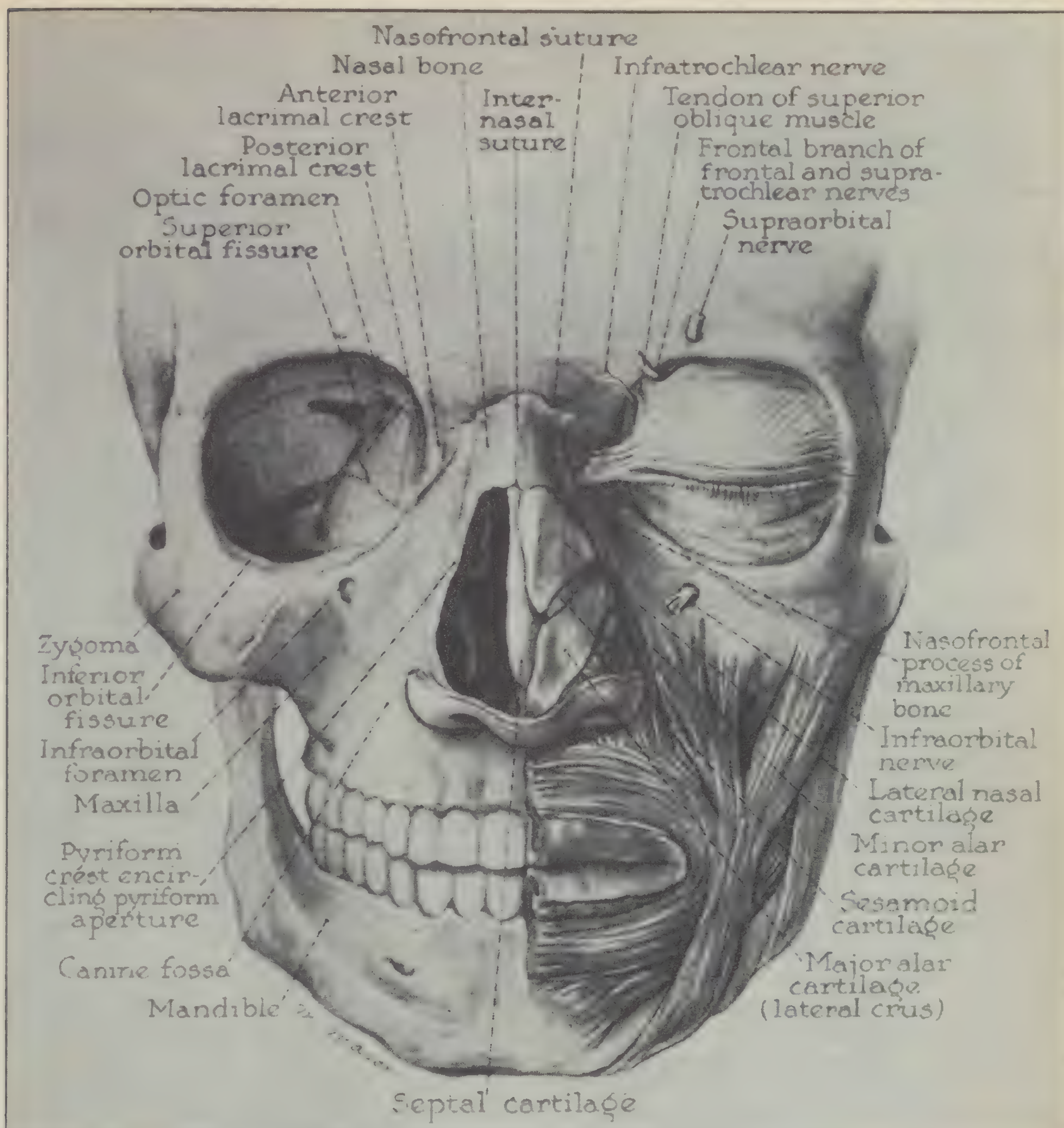


Figure 5-9.

THE NOSE AND PARANASAL SINUSES

Anatomy.—The skeletal structure of the nose is composed partly of bone and partly of cartilage. The small flat nasal bones and the piriform crests of the maxillary bone give shape to the rigid upper part of the nose. The lower movable part is composed of two pairs of flat hyaline cartilage, the upper pair of which is continuous with the cartilage of the nasal septum. Certain small accessory cartilages help give shape to the alae laterally.

Internally the cavity of the nose is divided into roughly equal passages by the nasal septum. Anteriorly the septum is cartilaginous

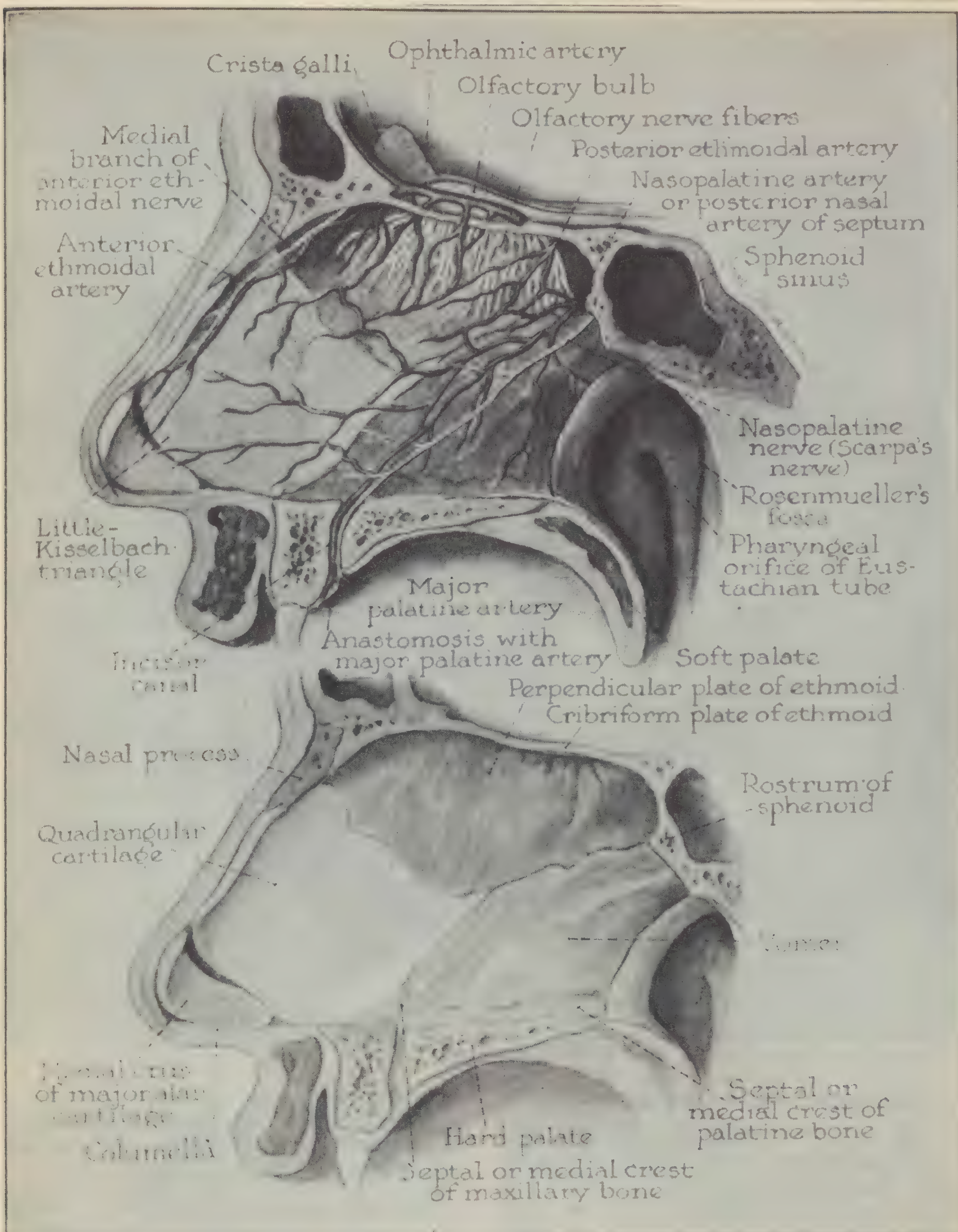

Crista galli
Ophthalmic artery
Olfactory bulb
Olfactory nerve fibers
Posterior ethmoidal artery
Medial branch of anterior ethmoidal nerve
Nasopalatine artery or posterior nasal artery of septum
Anterior ethmoidal artery
Sphenoid sinus
Nasopalatine nerve (Scarpa's nerve)
Rosenmueller's fossa
Little-Kisselbach triangle
Pharyngeal orifice of Eustachian tube
Major palatine artery
Anastomosis with major palatine artery
Soft palate
Perpendicular plate of ethmoid
Cribriform plate of ethmoid
Nasal process
Rostrum of sphenoid
Quadrangular cartilage
Septal or medial crest of palatine bone
Hard palate
Septal or medial crest of maxillary bone

Figure 5-10.

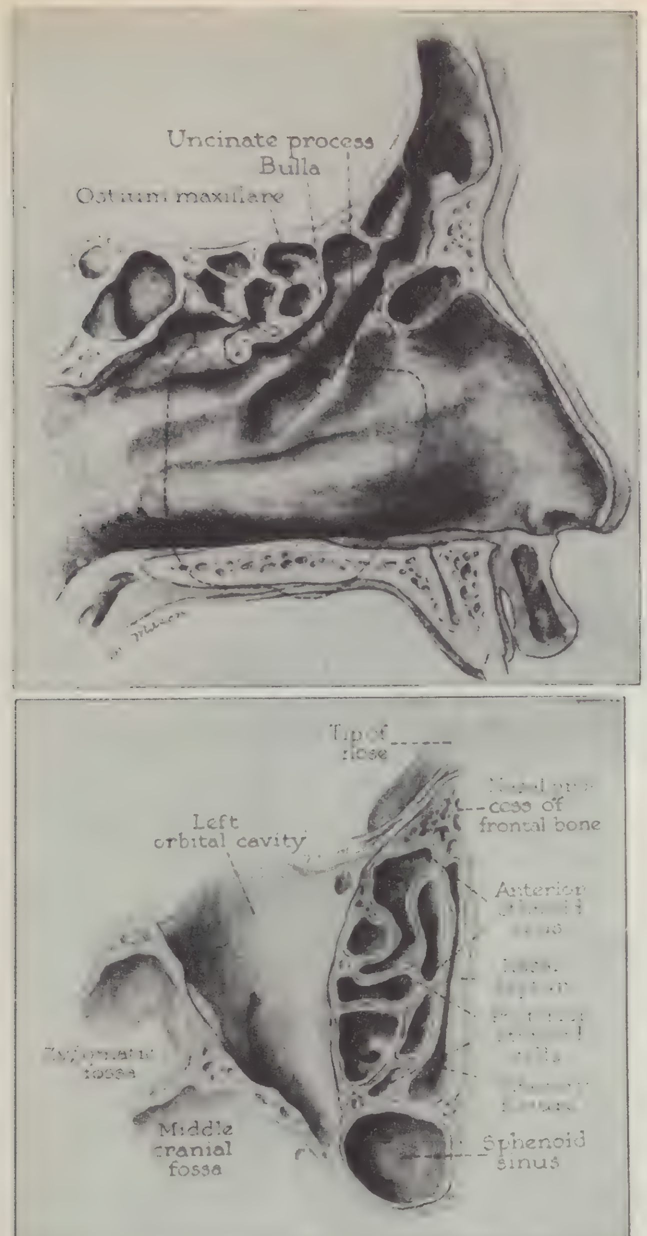


Figure 5-11.

for the most part. The ploughshare shaped vomer bone, firmly attached to the maxillary and palatine bones which form the floor of the nose, is the bony support of the septum posteriorly and superiorly, is filled by the perpendicular plate of the ethmoid. These structures are covered by mucous membrane.

Laterally the nasal wall presents an irregular surface convoluted by the nasal turbinates. Inferiorly the lateral wall is formed by the superior maxilla. Just above this the inferior turbinate is inserted into a triangular space. Superiorly the wall is formed by the lateral wall and processes of the ethmoid while the lacrimal bone occupies a small space anteriorly. The posterior portion is completed by the perpendicular portion of the palatine bone and the medial plate of the pterygoid process of the sphenoid.

The lateral wall presents three or more shelf-like processes which hang down into the nasal cavity. These are called turbinates. These are thin shells of bone covered by mucous membrane which greatly increase the mucous membrane surface of the nasal cavity. The inferior turbinate is a separate bone and the largest of the turbinates. The middle and superior turbinate are outgrowths from the ethmoid labyrinth.

The space below the inferior turbinate is called the inferior meatus. The nasolacrimal duct drains into this space anteriorly. The middle meatus under the middle turbinate contains many important structures. The most important of these is a long narrow groove, the hiatus semilunaris. Its importance lies in the fact that it drains all the anterior paranasal sinuses. These include the maxillary, frontal, and most of the ethmoid cells. A few ethmoid cells, known as the posterior ethmoids, drain into the superior meatus above the middle turbinate.

The roof of the nasal cavity is formed by the cribiform plate of the ethmoid capsule. It is perforated by 20 or more small openings through which pass the terminal branches of the olfactory nerve. Posteriorly and inferiorly the nasal cavity opens into the nasopharynx. Above is the curved surface of the sphenoid bone. The sphenoid sinuses drain into a narrow slit between the sphenoid and ethmoid bones called the sphenoethmoid recess.

The mucous membrane of the nose varies somewhat in different places. In the lower part, especially over the inferior turbinate, the mucous membrane is pseudostriatified columnar oiliated with many serous and mucous glands and a rich venous blood supply. In the upper straits of the nose the mucosa becomes non-ciliated and columnar in character.

The blood supply to the nose comes from different sources: from the ophthalmic branch of the internal carotid, the internal maxillary

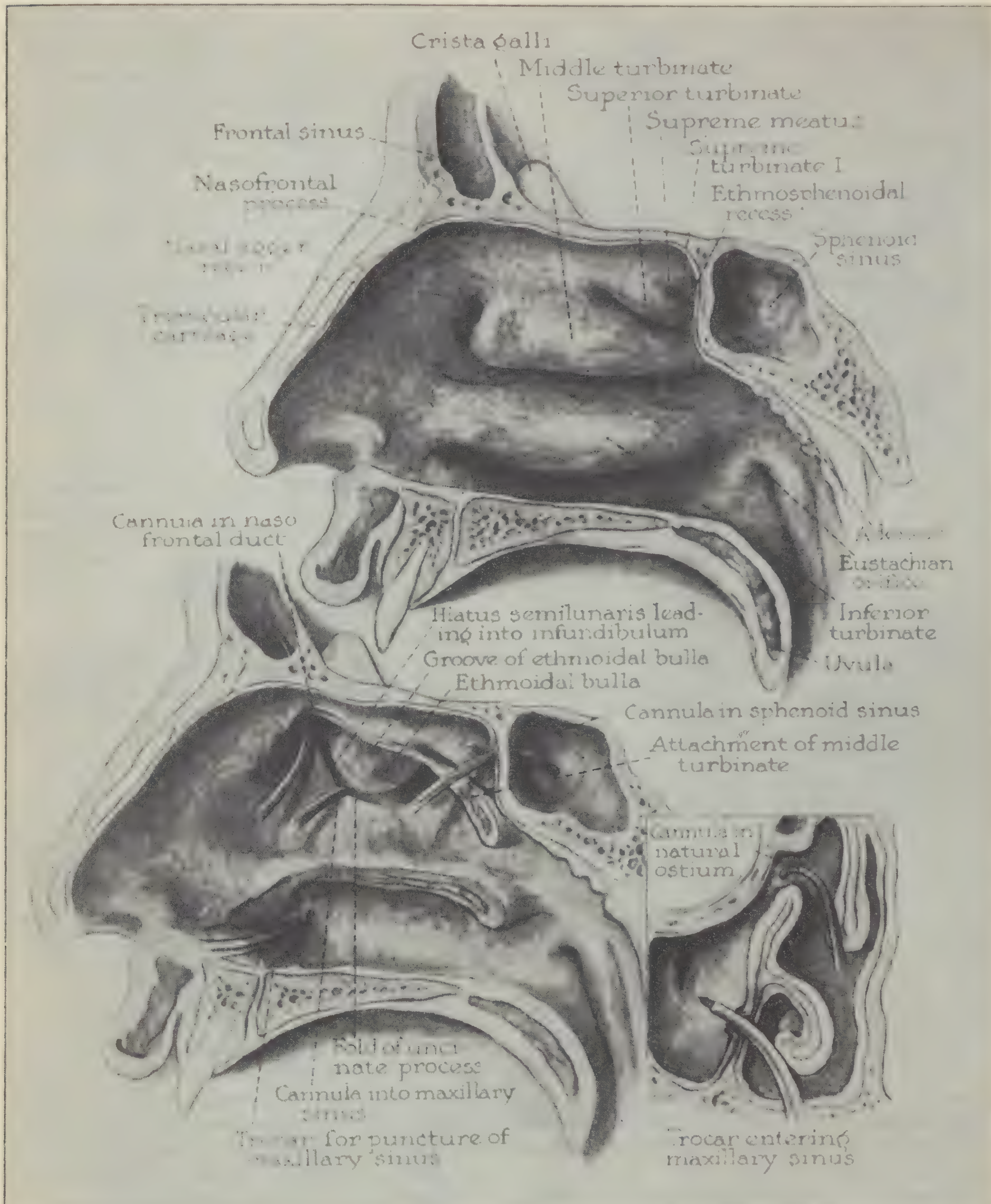

Crista galli
Middle turbinate
Superior turbinate
Supreme meatu
Frontal sinus
turbinate I
Nasofrontal
Ethmosphenoidal
recess
Sphenoid
sinus
Cannula in naso
frontal duct
Eustachian
Hiatus semilunaris lead-
ing into infundibulum
Inferior
turbinate
Groove of ethmoidal bulla
Uvula
Ethmoidal bulla
Cannula in sphenoid sinus
Attachment of middle
turbinate
natural
ostium
nate process
Cannula into maxillary
for puncture of
maxillary sinus
Trocar entering
maxillary sinus

Figure 5-12.

branch of the external carotid and branches from the facial artery. The sensory nerves come from the first and second divisions of the Trigeminal nerve.

The paranasal sinuses.—The paranasal sinuses are divided into two groups, posterior and anterior. The dividing line is the attachment of the middle turbinate. Sinuses draining below the attachment of the middle turbinate are the anterior group. These include the frontal, maxillary and most of the ethmoid group of cells. The posterior group includes the few ethmoid cells which empty into the superior meatus and the sphenoid sinuses which drain into the spheno-ethmoid recess.

The sinuses are formed as invaginations of mucous membrane from the nasal cavity with subsequent pneumatization of the bones for which they are named. The degree of pneumatization which takes place varies greatly in different individuals. Even in the same individual the sinuses may not be of the same size on the two sides. There may be complete absence of a sinus on one side with a well developed cell on the opposite side. All sinuses must have an opening into the nasal cavity for ventilation and drainage. In about 40 percent of cases the maxillary sinus has one or more accessory openings.

Blood supply.—Arterial supply is from the ophthalmic division of the internal carotid (anterior and posterior ethmoid arteries) and the internal maxillary artery from the external carotid. The venous drainage is primarily to the pterygoid plexus via the sphenopalatine foramen, but there are also anastomoses with the ophthalmic and the anterior facial veins.

Innervation.—The sensory nerves to the sinuses are from the first and second division of the trigeminal nerve.

Functions of the nose—Filtration, warming, and humidification of the air, preparing it for the lower air passages, are the primary functions of the nose. Olfaction is the next most important. The nasal cavity also acts as a resonating chamber in phonation. The nasal secretions possess a strong bacteriostatic property. The nose is also the origin and recipient of numerous reflex arcs.

Filtration is accomplished in two ways. The vibrissae in the vestibules strain out coarse particles of dust or lint. In addition the entire mucous membrane surface of the nasal cavity is covered by a sheet of mucous which entraps foreign matter, including bacteria. By the action of the cilia this mucous sheet is continuously being moved backward toward the nasopharynx where it is either swallowed or expectorated. The cilia move the secretions at the rate of about 5 mm. per minute. It is constantly being replaced by the mucous glands of the mucous membrane.

Inspired air is warmed by heat transfer from the mucous membrane, especially of the turbinates. It picks water vapor from the same source. If the mucous sheath were not being continuously replaced the membranes would become dry, the cilia would be inactivated and the principal functions of the nose destroyed.

The functions of the paranasal sinuses are not so well known. It has been suggested that they reduce the weight of the head, that they act as reservoirs of warmed and humidified air, and that they act as resonators for the voice. Our primary interest in these cavities is to be sure that they are adequately ventilated and drained. They are lined with mucous membrane continuous with that of the nasal cavity proper. So long as the natural openings remain unobstructed the cilia keep the sinuses empty and in a healthful condition. But it must be remembered that the sinuses are continuous with the nasal passages and that any condition involving the nose may involve the sinuses also.

DISEASES OF THE NOSE

Malformations.—The size and shape of the external nose varies considerably in different individuals. In addition to racial and familial characteristics there are also deformities due to trauma. These are not considered disqualifying so long as they do not interfere with the functions of the nose.

The common cold.—Colds are classified as bacterial, virus, and allergic. Chilling is an important predisposing factor. Other factors are fatigue, damp clothing, poor ventilation, nasal obstruction, or chronic infection of the mucous membrane of the nose and sinuses. Pathological findings include ischemia, hyperemia, exudation, and extravasation of serum.

Later the secretions become thicker, more mucoid and contain pus cells and surface epithelium. The congestion gradually subsides and the mucosa returns to normal.

Complications of the common cold may involve the sinuses, the ear, the larynx and bronchi. The garden variety of headcold is the cause of more lost man-hours than any other disease. Its complications add greatly to this already formidable total. It is because of the complications of otitis and sinusitis that the flight surgeon must forever be educating his flight personnel of the dangers of flying when they have only "a little nose cold." We have already discussed aero-otitis media. The common cold is the direct cause of this condition in a great percentage of cases. It requires only a slight amount of congestion of the mucous membrane of the nasopharynx to occlude the pharyngeal opening of the Eustachian tube.

Aerosinusitis.—Any obstruction to drainage of the sinuses results in absorption of the air in the sinus cavities, stagnation of the secretions in the sinus, followed by bacterial growth and the formation of pus. These conditions are associated with headache, tenderness over the sinus involved and usually a purulent nasal discharge. Like aero-otitis, aerosinusitis usually developed during descent from high altitudes. Congestion in the nose prevents air from entering the sinus to equalize the increasing pressure of the atmosphere. Negative pressure increases in the cavity. The subject is aware of discomfort followed by severe pain over the sinuses involved, usually above or below the eye. Returning to higher altitudes relieves the symptoms.

Treatment of diseases of the nose and sinuses has as its objective the return of adequate ventilation and drainage. The common cold we still treat symptomatically with vasoconstrictors, salicylates, and codeine. If the condition is on an allergic basis the new antihistaminic drugs are frequently of value. In suppurative conditions the sulfa compounds and antibiotics are used.

Allergy.—We can but mention this very important subject. Personnel with nasal symptoms of allergy (hayfever, polyposis, asthma) should be screened out during the selection of flight personnel. A careful family and personal history coupled with the findings of the telltale pale boggy mucous membranes and/or the presence of nasal polyps should usually suffice to prevent these people from receiving flight instruction.

Diseases of the nasal septum.—Many serious inflammatory conditions of the nose and sinuses are due to abnormalities of the nasal septum. The septum is rarely completely straight. Slight deviations and curvatures are not unusual. They are not important unless they interfere with the normal functions of the nose. Spurs or ridges in the lower portion may cause no inconvenience. Abnormalities higher up pressing on the middle turbinate may well obstruct the drainage of the anterior group of sinuses which empty into the hiatus semilunaris under the middle turbinate.

Trauma to the nose is not uncommonly followed by hematoma of the septum. The appearance is that of reddened masses occluding one or both nares, without other signs of local inflammation. If small, they may be allowed to absorb: more commonly, they are drained through a short incision in the dependent part of the mass. If they become infected a septal abscess may result. In addition to swelling, redness and edema of the septal mucosa, there is swelling, pain, and redness of the external nose. The abscess cavity is drained surgically and the opening maintained by a small drain until the abscess cavity is obliterated.

Epistaxis.—Most nosebleeds occur from the area on the septum just inside the vestibule, known as Kisselbach's area. Here the different arterial sources to the septum anastomose in a very vascular plexus. Trauma is perhaps the most common direct cause, but various diseases of the nasal membrane, violent blowing of the nose, sneezing, the inhalation of irritating dust and tumors all contribute. Epistaxis from the various types of cardiovascular disease are not frequently seen among flying personnel.

The first step in treatment is to find the bleeding point. If the bleeding is anterior this is not a difficult matter. A good suction apparatus is a good deal of help in these cases. Frequently temporary control of bleeding can be obtained by compression of the nasal tip between thumb and finger for a few minutes. The bleeding point may then be located and touched

with strong silver nitrate, chromic acid, or the actual cautery. When the bleeding vessel cannot be localized it is frequently necessary to pack the nose, using an anterior or posterior pack, or both. Quite often the control of a severe nosebleed will try the patience, skill and ingenuity of the surgeon.

Sinusitis.—Sinusitis may be present at all ages and respects neither season nor climate. The extent and persistence of the condition depends on two major physiological principles: ventilation and drainage. Treatment is always directed toward the improvement of aeration and drainage. The antibiotics and sulfa compounds are extremely helpful but drainage through natural or surgical openings must be established before one can expect a cure.

Maxillary sinusitis.—In acute maxillary sinusitis the predominant symptom is severe neuralgic pain referred to the cheek on the affected side, above the eye, or in the upper dental arch. There is tenderness to pressure over the involved sinus. As the condition becomes purulent the symptoms are aggravated. Sometimes the disease is secondary to a dental infection. A foul odor to the discharge is characteristic of dental infections. Headaches are common, particularly when the natural ostium is occluded. Nausea, vomiting, and dizziness are not uncommon. There is usually discharge oozing from under the middle turbinate.

Chronic maxillary sinusitis results when the acute condition fails to clear up under local treatment. The exudate becomes organized, the mucous membrane lining thickened and polypoid. Polypoids growth may project into the middle meatus. When in doubt, irrigation of a suspicious appearing antrum aids in diagnosis. X-rays also are of value in doubtful cases.

In the treatment of sinusitis, regardless of location, ventilation, and drainage are the two principles we try to promote. Shrinkage of the nasal membranes followed by mild suction is helpful in many cases. Steam inhalations, infra-red and diathermy all have their place. Once the acute condition has subsided irrigation of the antrum, either through the natural ostium or by means of a trocar under the lower turbinate, should be done periodically. If irrigation twice a week fails to show signs of improvement after a few weeks more radical measures become necessary. If the infection is dental in origin it is useless to attempt to cure the sinusitis while the offending tooth remains in place.

Frontal sinus disease.—Symptoms: frontal pain and tenderness, sometimes referred to the temporal regions. The pain is aggravated by blowing the nose or coughing. Fever, leucocytosis, and generalized toxicity may be present. If the nasofrontal duct is obstructed fistulous tracts may develop. The bony floor of the sinus is quite thin and it is here that fistulae most commonly occur. But the pus may break into the ethmoid labyrinth, the nasal cavity, the orbit, or the cranial cavity, resulting in meningitis and brain abscess. Osteomyelitis of the skull is one of the most feared and dangerous complications.

If the condition fails to respond to local treatment along with penicillin or sulfadizaine, surgical measures must be considered. The simplest and perhaps the safest approach is to trephine through the floor of the sinus. A rubber drain is sutured into the trephine opening and allowed to remain there as long as purulent drainage persists or until drainage into the nose is established. Fortunately most of cases respond to intranasal shrinkage, local heat, and the systemic use of penicillin.

Esthmoid sinusitis.—The anterior ethmoid cells are in close proximity with the frontal and maxillary sinuses. Furthermore, all drain into the hiatus semilunaris, under the middle turbinate. As a consequence it is seldom that one of these sinuses is diseased without some involvement of the others. Similarly, the posterior ethmoid cells may become infected from the sphenoid sinuses. As a group the ethmoids are probably more prone to infection than any of the other sinuses. In the acute form there is always a certain amount of involvement of the mucous membrane of the nose to complicate the picture. The symptoms are not clear cut but there is usually pain over the root of the nose, frontal headache, and nasal discharge. Transillumination and external pressure over the frontal and maxillary sinuses help to exclude them as the source of the discharge. A swollen upper lid is associated with frontal sinus disease, while swelling of the lower lid is characteristic of ethmoiditis. Swelling of both

lids indicates combined involvement. Proptosis of the eyeball may result from rupture of an ethmoid infection into the orbit. Movement of the eyes may be painful due to a periostitis about the pulley of the superior oblique muscle. The appearance of the middle turbinate is frequently helpful in diagnosis of ethmoid disease. In the early stages of the disease the middle turbinate is red and swollen. Later it may assume a polypoid appearance with markedly thickened mucous membrane. Pain is rare in the chronic form but there is a sensation of chronic dryness and secondary pharyngitis which causes discomfort.

Treatment.—Conservative measures are tried first, shrinkage, suction, chemotherapy, and local heat. If indicated a submucous resection or fracture of the middle turbinate should be done to improve drainage from the middle meatus. Removal of the middle turbinate is a further measure to be followed by uncapping or exenteration of the ethmoid cells. As a last resort the external ethmoid operation may become necessary as a lifesaving measure or because more conservative measures have been unsuccessful.

Sphenoid sinus disease.—Inflammation of the sphenoid sinuses may be a direct extension from disease of neighboring sinuses, the nasal mucous membrane or from the nasopharynx. The ostia of the sphenoids open into the ethmosphenoid recess and may easily become obstructed by swelling of the mucous membrane. The symptoms are variable but may consist of a deep boring headache, occipital or parietal, inability to concentrate, and associated with malaise and anorexia. In the chronic cases symptoms are so variable that certain writers have even described a characteristic pain in the arch of the foot. Symptoms may appear as ocular, aural, intracranial, mental or systemic manifestations. Pain is frequently referred to the mastoid area. Rupture may take place into the orbit, the ethmoids or the cranium with the development of a rapidly fatal meningitis. Cavernous sinus thrombosis is another feared complication.

Examination of the nose and nasopharynx may show little or nothing. In chronic cases there is usually hypertrophy of the lateral lymphoid bands in the pharynx with the presence of thick greenish tenacious exudate. Postrhinoscopy may show the pus oozing downward from the ethmosphenoid recess on one or both sides. If orbital extension has occurred there may be proptosis, paralysis of the extraocular muscles with chemosis and swelling of both lids. Examination of the nose may show pus coming from above the middle turbinate.

Treatment of sphenoid disease follows the pattern laid down for the other sinuses. Surgical intervention must be done with extreme care because of the close proximity of the sphenoid sinus to the orbit, the optic nerve and chasm, the cavernous sinus, the meninges, the pituitary body and the internal carotid. As dehiscences may occur in the sphenoid bone any of the above may lie under the mucous membrane of the sphenoid sinus.

Infections of the mouth and pharynx.—The pharynx is part of both the alimentary tract and the respiratory tract and is subject to lesions peculiar to both of these systems. The functions of the mouth and pharynx include mastication, salivation, the organ of speech and an important auxiliary respiratory system. Any lesion interfering with these natural functions is disqualifying. We can mention but a few of the more common conditions which not only cause discomfort to the patient but are an important cause of lost man-hours.

Acute pharyngitis.—As the pharynx is directly continuous with the nose it is to be expected that a certain degree of pharyngitis will accompany any infection of the upper respiratory tract. It is a sufficient cause for grounding flying personnel. In addition to the local treatment to the nasal membranes, hot saline irrigations of the pharynx are comforting and beneficial. Analgesic drugs (codeine and aspirin), forced fluids, and specific chemotherapy should be used when susceptible organisms are found.

Tonsillitis.—When the tonsils alone are diseased the term "tonsillitis" is applicable. But tonsillitis and "sore throat" are generally used synonymously. The infection of the tonsils is commonly only the local manifestation of a more general disturbance which has its original focus in some part of the upper respiratory tract.

Acute peritonsillar abscess or quinsy sore throat is due to an extension of a tonsillar in-

fection into the loose peritonsillar tissues with abscess formation. Seen early it can sometimes be absorbed by prompt antibiotic or chemotherapy. More commonly it requires surgical intervention.

Tonsillitis chronic.—The question of whether or not tonsillectomy is indicated is constantly being met. It is well for the surgeon to have in mind a routine for the handling of these cases. A history of repeated attacks of tonsillitis, or peritonsillar abscess, hypertrophied tonsils which obstruct breathing or deglutition, or tonsils suspected of being foci of infection are all adequate indications for tonsillectomy.

Chronic pharyngitis.—This is usually due to irritation of the mucous membrane. An outstanding example is excessive smoking. Another common cause is chronic drainage from a low grade sinusitis or chronic rhinitis. Elimination of the underlying cause will frequently result in relief of symptoms.

Infectious mononucleosis.—This is but one of the blood disturbances with findings referable to the pharynx. It is perhaps the most common. The symptoms are those of pharyngitis, tonsillitis, and influenza. In some cases fever persists for several weeks. Cervical adenopathy and tenderness appear promptly. Dysphagia is pronounced. The acute reaction usually lasts about ten days followed by a slow convalescence. The blood picture is characteristic. It is assumed to be due to a filtrable virus, although the fusospirochetal organism is commonly found in the ulcerations of the mucous membranes. Lymphocytosis, relative and absolute is about 50 percent greater than normal, with great variations in the total white cell count. A large percentage of the mononuclear cells are of the intermediary or large types. There is no specific treatment.

QUESTIONS on OTOLARYNGOLOGY

1. Discuss briefly the anatomy of the external auditory canal.
2. Discuss factors to be considered in dealing with foreign bodies in the external auditory canal.
3. Describe the normal tympanic membrane.
4. Outline the management of a case of otomycosis including symptoms, findings, treatment and possible complications.
5. Discuss the physiology of aero-otitis media.
6. Describe the anatomy of the medial wall of the middle ear cavity.
7. Describe the Eustachian tube. What is its function?
8. Discuss briefly the anatomy of the inner ear.
9. Define: (*a*) oval window, (*b*) stapes, (*c*) endolymph, (*d*) nystagmus, (*e*) vertigo.
10. A pilot flying on instruments goes into a spin to the right. Ignoring his instruments he recovers only to go into another spin to his left. Discuss physiology involved.
11. Describe briefly: (*a*) Rinne test, (*b*) Weber test.
12. Indicate the type of deafness caused by (*a*) foreign body in the external canal, (*b*) retracted tympanic membrane, (*c*) tumor of auditory nerve, (*d*) acute labyrinthitis.
13. Discuss the resonance theory of Helmhotz.
14. Mouth breathing is detrimental to health. Why?
15. While making a run on a target a divebomber pilot experienced sudden severe pain over right eye. Discuss probable cause, prevention, and treatment.
16. Discuss the functions of the nose.
17. Discuss the importance of cilia of nasal mucous membrane.
18. The tensor palati and levator palati muscles are important in flying. Why?
19. An applicant for flight training has a deviation of the nasal septum which presses on a middle turbanate. Explain why this is disqualifying.
20. Explain why a man with conductive deafness hears better over the telephone than a man with perceptive type of deafness.

BIBLIOGRAPHY

1. *Textbook of the Ear, Nose and Throat.* Lederer and Hollender, F. A. Davis Company, Philadelphia, 1947.
2. *Aviation Otolaryngology.* Army Air Forces, School of Aviation Medicine, Randolph Field, Texas.
3. *Diseases of the Ear, Nose and Throat.* Jackson and Jackson. Saunder, Philadelphia, 1945.
4. *Diseases of the Nose, Throat and Ear.* Ballenger. Lea and Febiger, Philadelphia, 1943.

CHAPTER 6

THE CARDIOVASCULAR SYSTEM IN AVIATION MEDICINE *

The human body is ordinarily regarded as a unit, both anatomically and functionally. As such it has great powers of adaptation to changing environment and possesses a remarkable range of physical and mental capability. All this is made possible through the functional integrity of the millions of cells of which the body is composed. Most of these cells live essentially a unicellular existence, not unlike that of the simple forms of aquatic life, and require a fluid environment of a relatively constant character. These conditions are met and maintained only through the continual and successful functioning of many physiological mechanisms not the least of which are the circulatory and lymphatic systems.

The importance of the cardiovascular system in aviation rests on the fundamental fact that this system may be one of the limiting factors in man's adaptation to the exacting and sometimes abnormal stresses encountered in flight. Thus, it becomes necessary to evaluate the cardiovascular status and reserve in terms of the type of flying to be done. If it is apparent that this reserve will be exceeded then an attempt should be made to alter the circumstances in flyer or plane, or failing this, to define the limitation. Theoretically at least, all persons can be classified with respect to their capacity to take part in flying activities. A consideration of various factors in flying which affect the cardiovascular system may well begin with the simple fact that piloting a plane ultimately depends on the human organism and requires the continuous attention of the pilot.

* Prepared by Captain Ashton Graybiel, (MC), USN.

The immediate purpose of the circulatory system is to provide a continuous flow of blood to the capillaries and to regulate this flow in accordance with the ever-changing metabolic requirements. Food and oxygen are carried to the tissues and waste products are carried away to the lungs and kidneys. The circulation also plays an important role in heat regulation, in distributing various secretory products and in integrating many bodily functions.

The cardiovascular system consists essentially of the heart, arteries, veins and ramifications of minute vessels, the smallest of which are the capillaries. These several divisions function independently in varying degrees but the system as a whole is highly integrated, chiefly by means of nervous and chemical influences.

THE HEART

The heart may be regarded as a highly differentiated portion of the circulatory system. It consists of two main pumping units, each of which receives blood at low pressures and discharges blood at relatively high pressures. The chief function of the heart is to pump on all the blood it receives. The right heart receives venous blood returning via the great veins and sends it into the pulmonary circuit. The oxygenated blood returning to the left heart is pumped onward into the systemic circuit. Although both left and right hearts contract simultaneously and are in other respects interdependent, yet each pumps blood at different pressures and is in other ways functionally independent. This is clearly illustrated in the altered dynamics following predominent injury and failure of one ventricle.

The cardiac cycle.—The cardiac cycle has been divided into two chief phases, ventricular systole and diastole. The systolic phase begins with the contraction of the ventricular musculature and ends with the onset of relaxation. When the intraventricular pressure has risen slightly the mitral and tricuspid valves, which have already floated into position, are closed. Closure of these valves is mainly responsible for the first heart sound, there being an additional sound element from the muscular contraction of the ventricles. Intraventricular pressure rises rapidly until the semilunar valves are forced open. The ejection of blood proceeds rapidly at first, then slows after the major displacement of blood into the aorta has occurred.

Diastole begins with the relaxation of the ventricles and ends with their contraction. At a heart rate of 75 a minute it occupies nearly twice as long a period of time as systole. The sharp fall in pressure in early diastole is quickly followed by the closure of the semilunar valves which prevents the regurgitation of the blood into the ventricles. The simultaneous closure of both aortic and pulmonary valves is responsible for the second sound which is usually of high pitch and snapping in character. As the intraventricular pressure falls below that of the auricles the A-V valves open and blood flows from auricle to ventricle. This flow is rapid at first because of the volume of blood stored in the auricles and is associated with the physiological third sound which is sometimes heard. There follows a period of slower ventricular filling until the final augmentation due to auricular systole which terminates the period of ventricular diastole.

The intrinsic control of the heart beat.—The heart has its own system of specialized conduction tissue consisting of the sinoauricular (S-A) and auriculo-ventricular (A-V) nodes, the bundle of His and its branches and the Purkinje network. The S-A node or pacemaker is an elongated mass of delicate neuromuscular fibers lying along the sulcus terminalis at the junction of the superior vena cava and the right auricle. The A-V node lies in the posterior interauricular sulcus near the orifice of the coronary sinus. From it fibers arise which cross the A-V septum, pass forward in the lower part of the membraneous septum where they separate into left and right branches. These fibers are called the bundle of His and form the only direct muscular connection between auricles and ventricles. The left and right bundle branches continue down into the left and right ventricle where, after numerous subdivisions, they terminate in delicate strands called Purkenje fibers, which are distributed to the muscle fibers of the ventricles.

The excitation stimulus arises in the S-A node (pacemaker) from whence it spreads rapidly across the auricles stimulating the muscle fibers to contract. The auricular contraction which follows also spreads wavelike across the auricles in peristaltic fashion, and, in the case of the right auricle, directs the flow of blood away from the great veins toward the ventricle. When the excitation wave reaches the A-V node it discharges the stimulus building there and is led by way of the specialized conduction tissue to all or nearly all of the ventricular muscle fibers. This results in simultaneous activation of the ventricular musculature and hence effective contraction. The heart, in common with other muscular tissues, readily displays electrical activity when stimulated and a record of the potential variations associated with the spread of the excitation wave is observed in the electrocardiogram.

The most important feature of cardiac physiology is concerned with muscular contraction and the law of the heart. The law of the heart, or Starling's Law, simply states that within physiological limits the work capacity of the heart varies with the diastolic volume. In other words, the strength of contraction increases with increased stretch and lengthening of the muscle fibers. It is chiefly by virtue of this fact that the heart can readily adjust to variable loads placed upon it either through variations in the venous return or through alterations in arterial pressure.

Let us assume for the moment that the venous return to the heart is increased but that the heart rate remains constant. The venous pressure is increased, more blood will enter the ventricles during diastole, the muscle fibers are stretched to greater length and the ventricles will contract on a larger diastolic vol-

ume. This will result in a more forceful systolic contraction and a larger volume of blood will be displaced under a greater pressure. The reverse occurs when the venous return is decreased.

Again let us assume that the venous return to the heart and the heart rate remain constant but that the arterial pressure is suddenly raised. The subsequent contraction will not be sufficiently forceful to expel all of the blood against the increased pressure and a portion will remain in the ventricle. To this will be added the usual inflow during the next diastolic period. This results in an increased diastolic volume, increased diastolic length of muscle fiber, and as a consequence, a more forceful systolic contraction. In a few beats the adjustment will be made to the increased arterial pressure and the initial stroke volume will be regained.

The work of the heart.—It has been shown that the cardiac output in the same individual varies greatly depending on the circumstances and that, under similar (basal) conditions, the cardiac output in different individuals is a function of the surface area. The cardiac index has been defined as the cardiac output per square meter of body surface and has found that in young healthy persons under basal conditions it is 2.2 ± 0.2.

Some idea of the amount of blood the heart pumps over a period of time is readily gained from cardiac output estimations. Assuming that the cardiac output averages 5 liters per minute during the 24 hours of the day, then left and right would pump 14,400 liters, or about 75 barrels of blood.

The great reserve power of the heart is illustrated by the enormous increase in cardiac output as a result of exercise. The cardiac output of an average sized man at rest is in the neighborhood of four liters a minute and during strenuous exercise may rise to 30 liters a minute and has been measured as high as 37.3 liters a minute. Inasmuch as the right heart pumps as much as the left these figures should be doubled when considering the total output.

Heart failure.—Heart failure may occur suddenly or gradually as a result of disease or functional disturbance. The lesser degrees are manifest only by a decrease in reserve while in the advanced stages the heart may be unable to pump on all the blood returning to it even with the body at rest. In the early stages of heart failure, when that organ is put under a strain, compensation is effected by a relatively greater increase in diastolic volume than normally. In other words, with increasing degrees of heart failure the muscle fibers must stretch more and more to provide the same force of contraction. Eventually a limit is reached beyond which further stretching of the fibers results in a decreased ability of the heart to pump blood and the terminal stage of heart failure ensues.

The nervous control of the heart rate.—The heart rate is under the immediate control of the pacemaker (S-A node), the rythmical discharges of which are under the influence of the sympathetic (accelerator) and vagus (inhibitory) systems with "centers" located in the floor of the fourth ventricle. These centers can be influenced both reflexly and by the higher centers. The lability of the heart rate in response to emotional factors is well known. Other ways in which the heart rate can be reflexly affected include the following: (1) when rate is slowed and vice versa. This is sometimes referred to as Marey's Law. (2) When the pressure in the aorta is increased the heart the pressure in the carotid sinus is increased the heart rate is slowed and vice versa. (3) When the pressure in the right auricle and great veins is increased as a result of increasing venous return there is acceleration of the heart rate. This is often referred to as the Bainbridge reflex. (4) Somatic impulses may also reflexly affect the heart rate.

In the healthy man at rest the heart rate is usually between 50 and 80 a minute but these limits may occasionally be exceeded. Pulse rates as slow as 40 a minute have been observed in athletics but rates much above 80 should be regarded with suspicion if the subject is mentally and physically at rest. Emotional stimuli may increase the rate up to 140 or even higher, and during exercise the rate in an adult may reach 190. Abolishing the vagus impulse with atropine may cause an increase in rate up to 150 or slightly higher.

THE PERIPHERAL VESSELS

The aorta and large elastic arteries.—The aorta, and to lesser extent other large arteries, are relatively thin-walled and contain a large amount of elastic tissue. With each systolic discharge these vessels are distended and more blood is temporarily stored than is immediately passed onward to the smaller arteries. During diastole the arteries contract to their original size by virtue of their elasticity and this presses forward the blood stored during systole. Thus the intermittant flow of blood from the heart is transformed into a continuous but pulsitile flow in the periphery. In addition, special areas in the arch of the aorta and at the bifurcation of the carotid arteries contain nerve endings which are sensitive to stretching of the vessel walls.

The large muscular arteries.—Arteries such as the brachial and femoral have a strong median coat of circularly arranged muscle fibers which, when stimulated, can greatly reduce the size of the lumen. By such alterations in caliber the flow of blood to a particular organ or region may be markedly increased or decreased. This differential distribution of blood is initiated locally, probably by chemical influences and augmented by reflex vasodilatation in the active areas and vasoconstriction in other areas.

The arterioles.—The arterioles are minute arteries averaging about 0.2 mm. in outside diameter. The muscular coat, relative to the size of the lumen, is more strongly developed than in any other order or size of vessel. They are well supplied with vasomotor nerves and are normally subject to tonic vasoconstrictor impulses. The arterioles are the site of the greatest degree of peripheral resistance and hence the steepest fall in pressure gradient. This helps to maintain the arterial blood pressure and, at the same time, to protect the capillaries from high blood pressures. The immediate cause of essential hypertension is to be found in an abnormal degree of vasoconstriction of the arterioles.

Capillaries.—The capillaries consist of single-walled endothelial tubes and are rightly represented as forming the keystone of the circulatery system because here only are the vascular walls sufficiently thin to permit adequate interchange of fluids and gases between blood and tissues. Each organ contains the number of capillaries necessary for its maximum functioning needs but during rest many or most of the capillaries are closed. If most of the capillaries were dilated at the same time they would contain the entire volume of blood in the body. Capillary tonus is largely, if not entirely, under independent control and is regulated by local conditions. The pressure in open capillaries is usually low but varies greatly; the range being from a few to 50 or more mm. mercury. A closed capillary may remain so against a pressure as great as 110 mm. mercury.

Veins.—The blood, after passing through the network of capillaries and other minute vessels, is again collected into larger vessels, the veins, and returned to the heart. This narrowing of the vascular bed increases the rate of flow but the veins have thinner walls and much larger capacity than the corresponding arteries. They are readily distended with blood and collapse easily when emptied. The veins are in a state of tonic contraction under the control of the vasomotor center and also respond to local physical and chemical stimuli. Veins with a diameter of one mm. or greater have valves so arranged that the contained blood can only move centrally. These valves are best developed in veins of the extremities and are absent in the large veins in the abdominal cavity, the veins of the head and neck and in certain other veins.

Venous return to the heart.—There are a number of factors which aid in returning the venous blood to the heart, the most important of which are the following: (1) The pressure and volume flow of blood in the capillaries. (2) Valves which direct the blood centrally. (3) Muscular tonus and the messaging effect of active muscles. (4) The pressure gradient in the abdominal cavity; the intestinal contents are thought to act like a fluid mass and consequently the pressure on the veins is much higher in the lower than in the upper part of the abdomen. (5) The aspirating effect in the

thorax produced by inspiration. (6) Gravity assists in the return of blood from the upper part of the body.

THE CORONARY CIRCULATION

The coronary circulation is unique in several respects and requires special consideration. About 5 percent of the cardiac output flows through the two coronary arteries which supply the heart.

A large but varying proportion of blood passes through the capillaries and is returned to the right auricle by way of the coronary sinus. A small proportion of the blood passing through the capillaries returns to the heart chambers directly via the Thebesian veins. Also, blood in the coronary arteries may reach the heart cavities directly via small anastomotic vessels and by way of the myocardial sinusoids.

During systole, as the heart muscle contracts on its contents, intramuscular pressure is raised to the point where coronary flow is greatly reduced. According to Wiggers, intramural pressure never equals the aortic and "the myocardium receive approximately three-fourths as much blood during systole as during an equivalent interval of early diastole but. of course, much less than during the entire period of diastole on account of its greater duration."

The single most important factor in determining coronary flow in the normal heart is the pressure of blood in the aorta, particularly mean pressure. Other factors of importance are the effects of vasomotor and local chemical effects. The coronary vessels are thought to be under tonic vagal control and to dilate as a result of vagal inhibition or sympathetic stimulation. Thus, there is commonly a greater tendency for the coronary arteries to dilate rather than to constrict. There is both clinical and laboratory evidence that the coronary vessels are dilated as a result of muscular metabolites and anoxia.

THE PORTAL CIRCULATION

Blood, after passing through the minute vessels of the spleen and most of the gastrointestinal tract, is not returned directly to the heart but just passes through the liver and hence through two sets of capillaries. The capacity of the portal system can vary a great deal and because of this the liver may function not only as a regulator of venous return but as a reservoir when the venous pressure in the right auricle is raised because of heart failure or other reason.

MECHANISMS CONTROLLING THE CIRCULATION AS A WHOLE

Although the regulation of the various divisions of the circulatory system have certain distinctive features, the system as a whole functions as a unit by means of various coordinating influences. The degree of integration is such that alteration of the circulation in one part of the system and in its regulatory mechanism, evokes responses in other parts in order to distribute the strain and to maintain the highest efficiency. The most important regulatory mechanisms are concerned with the maintenance of proper arterial and venous pressures. This is effected chiefly by means of true endovascular proprioceptive reflexes which originate in the great veins and right auricle, the aorta, and the carotid sinuses, and become effective after passing to the cardiac and vasomotor centers in the medulla. Chemical stimuli become generally effective after acting locally, and psychic stimuli after acting on the cardiac and vasomotor centers.

In aviation, unique stresses are applied to the cardiovascular system. Inasmuch as piloting aircraft is dependent upon the constant attention of the pilot, the functional integrity of the cardiovascular system must not be impaired even for a moment. The stress applied must not exceed the ability of the cardiovascular system to compensate. Certain types of failure of the peripheral circulatory system which would be regarded as of minor consequence in ordinary life might prove diastrous if they occurred in the pilot of a modern high performance military aircraft. It is therefore incumbent upon the flight surgeon or aviation medical examiner to exclude from an aviation career those applicants with structural and functional defects.

In aviation the stresses applied to the cardio-

vascular system are related directly to speed, acceleration, and maneuverability of aircraft. Should the stress applied exceed the critical level of cardiovascular adaptability of the individual, cardiovascular failure, either central or peripheral will result. The functional integrity of the pilot is lost or embarrassed and a hazardous situation is immediately precipitated.

It is apparent then that the flight surgeon must familiarize himself witth those stresses which are rather peculiar to aviation in order that he may correctly evaluate the individual's ability to withstand these forces. Certainly, three specific problems encountered in aviation are worth close scrutiny.

Acceleration.—Forces resulting from change in velocity or change in direction of motion may produce serious disturbances of circulation. These forces are the forces of acceleration and may be the result of (1) lineal, (2) angular, or (3) radial velocity changes.

Lineal acceleration is that force which is a result of change in velocity in a straight line path. It is manifested during take-off, at the moment a pilot's parachute opens, during bailout and at the moment of ejection in seat-ejection devices. More importantly, it is the main force acting in a crash.

The forces of lineal acceleration are usually high in magnitude, particularly in crashes, but active during a short time interval. At present, lineal acceleration exerts very little effect on the cardiovascular system either centrally or peripherally. It may in the future, however, be a much more important factor which will require consideration in the design of prone position aircraft or in aircraft having powerful seat-ejection devices.

Angular acceleration may be defined as change in angular velocity in unit time. It is the force encountered in skidding turns and in spins. The effect of the forces of angular acceleration upon the cardiovascular system is only of very slight consequence. Disorientation due to stimulation of the receptor organs of the inner ear is a very real threat to the functional integrity of the pilot and is the principle effect of angular acceleration.

The forces generated by changes in direction of motion are due to radial acceleration, which may be positive or negative in character.

The forces acting in negative acceleration are along the long axis of the body from feet to head. These are the forces experienced during outside loops, inverted spins, inverted snap rolls, etc. Inasmuch as the forebearers of the human organism were not required to exist in an inverted state, adaptive mechanisms were only feebly developed to assist man in returning blood from the head. When placed in the inverted position man's vascular system compensates very poorly. The additive strain of even slight accelerative forces applied in this position quickly overcomes the primitive mechanisms and their feeble response toward homeostasis with resultant pooling of blood within the cranium. This then may be spoken of as a rather special type of peripheral vascular failure which results in "red out," unconsciousness, and even intracranial hemorrhage depending upon the magnitude of the forces and the duration of their application. There are manifested individual variations in ability to withstand negative accelerative forces. However, even in those individuals who show some resistance to these forces, the total stress required to produce symptoms is of a minor magnitude.

Positive accelerative forces act from the head toward the feet and are encountered in sharp pull-outs, steeply banked turns and many acrobatic maneuvers. As previously stated, there are many factors operative in returning the blood from the lower extremities to the heart and which act to prevent pooling of blood in the periphery. The summation of these forces represents the total effective force acting to return the blood to the heart.

During the application of positive accelerative forces, the hydrostatic pressure of the blood column may exceed the total force of these compensating mechanisms and reflexes with resultant pooling of blood in the extremities, decreased venous return resulting in decreased cardiac output and cerebral anoxemia with "blackout," unconsciousness, convulsions, and finally death, again depending on time-intensity factors. Once more, it is to be noted that the primary failure is of the peripheral vascular system rather than the heart itself.

It is a well recognized fact that there are wide individual variations in ability to withstand accelerative forces. Thus, we find individuals who show marked resistance to the stress of positive acceleration. Again, there are individuals who manifest marked susceptibility to the forces of positive acceleration. Furthermore, it has been shown that variations in susceptibility may occur within the same individual from time to time. It is apparent, therefore, that susceptibility to the stresses of positive acceleration is a function of the efficiency of the peripheral vascular system. Any factor which tends to decrease the efficiency of the peripheral compensatory mechanisms will result in a lower tolerance to positive acceleration. What then is the role of the flight surgeon in combating these accelerative forces? It is incumbent on us to develop more protective mechanisms which will guard against or prevent failure of the peripheral vascular network. The development of highly efficient antiblackout suits should be a prime research topic. The research workers must devise aircraft in which the position of the pilot may be such as to minimize the stresses of acceleration.

The flight surgeon in practice must recognize those individuals showing marked susceptibility to positive acceleration. It is further necessary that he recognize those whose susceptibility is organic in nature, i.e., those showing true postural hypotension and other peripheral vascular states as distinct from those manifesting a transient decrease in efficiency of peripheral adaptive mechanisms as a functional result. It has been shown that with severe fatigue, following severe sunburn, during convalescence from a disease and following prolonged gastrointestinal upsets, the efficiency of peripheral vascular adaptive mechanisms may decrease alarmingly. Obviously, those individuals whose susceptibility is organic in nature should be prevented from flying military aircraft permanently. Furthermore, it is necessary to ground, at least, those showing a functional decrease in peripheral vascular efficiency.

Decompression sickness.—When the atmospheric pressure is sufficiently and quickly reduced symptoms may arise as a result of the formation of gas bubbles within the body. This bubble formation, of course, takes place in accordance with the laws governing the solubility of gases. Thus, at sea level the tissues are saturated with gases, chiefly nitrogen, oxygen, and carbon dioxide. When the atmospheric pressure is rapidly reduced, the tissues become supersaturated with these gases with the resultant formation of small bubbles composed largely of nitrogen. The symptom complex produced by localization of these bubbles in certain sites is spoken of as decompression sickness. The symptoms produced are mainly referred to the joints and extremities.

On occasion, however, an individual will manifest all the symptoms of peripheral vascular failure, e.g., paleness, perspiration, syncope, a precipitous fall in blood pressure and either a tachycardia or a bradycardia. Further studies on these individuals have shown that the heart itself is unaffected. The failure, then, is primarily within the peripheral vascular system. The fundamental precipitating factor in this loss of vascular efficiency has not yet been determined. The localization of gas bubbles within the medulla contiguous to the vasomotor centers has been hypothecated as a possible etiological factor. Amplification of this point awaits further investigative study.

Anoxia.—Because it is known that even the normal heart will dilate and fail if the oxygen supply is sufficiently reduced it has been commonly believed that even moderate degrees of anoxemia will not only affect the normal functioning of the cardiovascular system but actually damage the heart as well. Whether or not such damage may occur under the conditions met with in civil or military aviation deserves careful consideration.

In military aircraft most of the flying is still done at relatively low altitudes but some is done at elevations between 35,000 and 40,000 feet. At 40,000 feet the alveolar oxygen tension of a pilot inhaling pure oxygen corresponds to that of a pilot breathing air at 11,000 feet. From a practical standpoint it is nearly impossible to prevent slight leakage when using an oxygen mask so that the degree of anoxemia usually exceeds the theoretically calculated amount.

Because of the constant presence of some degree of anoxemia encountered in flight, it is

necessary that the flight surgeons know and understand the effects of oxygen deprivation upon the cardiovascular system.

Symptoms.—Healthy subjects during high altitude flight or exposed to low oxygen tensions in the laboratory rarely complain of symptoms directly referable to the heart. The dyspnea which may be noticed is not severe and is due to stimulation of the peripheral chemoreceptors by hypoxia and is not a sign of heart failure. Pain of cardiac origin is never noticed and palpitation very rarely.

Pulse rate.—Of all the circulatory changes due to diminished oxygen tension, acceleration of the heart rate has been studied the most. With successive decreases in oxygen tension the rate continues to increase slowly but the increase in rate is not marked until extreme degrees of anoxemia are reached.

Blood pressure.—The changes in blood pressure due to increasing hypoxia follow several fairly well recognized patterns. In the majority of healthy persons there is little change until the oxygen in the inspired air has fallen to low levels. Then there may occur a gradual rise in systolic and fall in diastolic pressure with consequent increase in pulse pressure. In susceptible persons exposed to moderate degrees of oxygen deficiency fainting may occur and there is a sudden fall in both systolic and diastolic pressure and an increase in pulse rate. This fainting reaction is in the nature of peripheral vascular collapse and is caused by cerebral anoxemia and is not due to heart failure. In a few subjects there is little change in blood pressure till unconsciousness supervenes. It is only at this stage of "crisis" that the fall in blood pressure may be directly attributable to a failing heart.

Cardiac output.—The cardiac output increases in healthy persons at rest under conditions of moderate hypoxia. This increase may be regarded as a compensatory or adjustment mechanism. With marked decreases in oxygen tension the cardiac output may fall as a direct result of cardiac anoxia but this stage is never reached under present flight conditions. More studies along this line are necessary before the relationship between anoxia and cardiac output is properly understood.

Heart size.—It is now quite generally agreed that the normal heart, if the subject is at rest, does not dilate even with greatly lowered oxygen tensions. This conclusion is borne out by animal studies in which it is shown that cardiac dilation does not begin until the oxygen saturation of arterial blood has fallen to about 50 percent or below.

The electrocardiogram and hypoxia.—The electrocardiographic changes have been studied during actual flight conditions as well as under conditions stimulating high altitudes in the laboratory. In healthy persons these changes consist of progressive lowering of the S-T segments and T waves with increasing hypoxia. Occasionally the T waves may be diphasic or even slightly inverted.

We know that there are many causes of lowering of the T waves which do not damage the heart and there is no good proof that the electrocardiographic alterations just described indicated myocardial damage.

In normal persons the symptoms which may appear under conditions of civil or military aviation and the associated changes in circulatory dynamics do not indicate heart failure but may be considered adjustments or compensatory reactions to the oxygen deficiency; the most trustworthy evidence supports the view that the normal heart is not damaged. In healthy individuals it is believed that the brain suffers from anoxemia long before the heart does, the latter enjoying a kind of enforced protection. The peripheral circulatory collapse that may occur in susceptible individuals even at relatively low altitudes depends primarily on a deficient supply of oxygen to the central nervous system.

Heart disease and hypoxia.—In turning from a consideration of the normal to the diseased heart we find good evidence that heart failure may be precipitated as a result of experimentally induced anoxemia in patients with heart disease. It would be strange indeed if this were not true. The surprising thing is that so few instances of heart failure have been reported and that those instances are restricted to patients with severe disease. Pain of cardiac origin has been observed occasionally as well as less specific symptoms of heart failure such

as marked dyspnea, weakness, and collapse. Congestion of the lungs has been noted occasionally and arrhythmias rarely. In addition to these symptoms and signs evidence of heart failure is seen in the increased circulation time, decreased cardiac output, increased venous pressure, and in the marked electrocardiographic changes which may occur.

In summary, it is evident that the degree of anoxia intentionally encountered under present flying conditions in civil and military aviation does not damage the normal heart. The changes observed in the electrocardiogram do not indicate heart injury; they are probably due in part to the alkalosis resulting from overventilation.

However, it is clear that heart failure of the congestive or anginal type has been produced in patients with severe degrees of heart disease on exposure to oxygen tensions simulating altitudes of 14,000 to 20,000 feet or higher.

It is thus apparent that in aviation certain rather profound specific stresses may be applied to the cardiovascular system. Furthermore, it is obvious that the effect of these stresses is dependent upon the integrity of the heart and the vascular system. Thus, the stresses normally encountered in flying, although affecting the normal cardiovascular system to some extent do not seriously embarrass it as a rule. However, as has been shown, these stresses applied to a faulty cardiovascular system may produce serious embarrassment and failure either of the heart itself or of the peripheral compensatory mechanisms. The flight surgeon must therefore be acutely conscious not only of the global effect of these stresses but also of the exact cardiovascular status of the pilot. It is necessary that he recognize those functional states which may produce cardiac failure as well as the various manifestations of organic heart disease. Of equal importance is the recognition of functional states of reduced pheripheral vascular efficiency as well as those disease states which produce inherent vasomotor instability.

It is necessary then to weigh the global effect of the stresses to be encountered against the cardiovascular system of the individual under consideration and from such examination to determine whether that individual is a good candidate for aviation.

BIBLIOGRAPHY

1. Abramson, D. I. *Vascular Responses in the Extremities of Man in Health and Disease.* Univ. of Chicago Press; 1944.

2. Best and Taylor *Physiological Basis of Medical Practice.*, Third Edition. Williams and Wilkins; 1943.

3. Graybiel, Ashton *A Consideration of the Effects of Oxygen Lack of the Cardiovascular System from the Viewpoint of Aviation.* Journal of Aviat. Med., 12, 1941.

4. Graybiel, Ashton and McFarland, Ross A. *The Use of the Tilt Table in Aviation Medicine.* Journal Aviat. Med.; 12, 1941.

5. Graybiel, Ashton, Patterson, John L. Jr., Packard, John M. *Sunburn as a Cause of Temporary Lowering of Blackout Threshold in Flyers.* Journal Aviat. Med. 19, 1948.

6. Grollman, Arthur, *The Cardiac Output of Man in Health and Disease.* Charles C. Thomas, 1932.

7. Howell, W. H. *Textbook of Physiology.* Edited by John C. Fulton, 15th Edit. W. B. Saunders, 1946.

8. Levine, S. A. *Clinical Heart Disease* 3rd Edit. W. B. Saunders, 1945.

CHAPTER 7

AVIATION PSYCHOLOGY *

Aviation psychology received its start during the first World War. Early beginnings were found in France and Italy, where in 1916 and 1917 respectively, standards were set for acceptance of candidates for flight training. By the end of the first World War, psychological as well as physical procedures were widely used by the nations involved, in the acceptance and rejection of aviation candidates. It has been pointed out in a report by the Committee on Selection and Training of Aircraft Pilots of the National Research Council that:

"Attention centered upon psychological methods in selection for the following reasons: (1) Despite selection on the basis of rigid physical examinations a large percentage of the trainees washed out; (2) among those who graduated from flight training courses some required up to twice as much training as others; (3) even after graduation there were large individual differences in proficiency; (4) accidents were in many instances attributed to psychological defects in the pilot; and finally, (5) there were many cases of nervous breakdown among flyers.

"It has also been pointed out that all of the psychological work done during the first World War fell under one or more of the following categories: tests of psychomotor processes including measurement of the speed of simple reactions and complex reactions and complex reaction tests; combinations of psychomotor and intellectual tests; investigations of sensory processes; personality observations; and investigations of psychological functions under low oxygen tension."

In spite of this beginning, however, aviation psychology came to an end soon after World War I. Even in the United States, in spite of the growth of aviation and the establishment of a School of Aviation Medicine, research by psychologists in the field of aviation was almost totally discontinued. The most important developments during the next fifteen years are traced in the report quoted above:

"Some studies of high altitude effects were carried out; an improved personality form for use in connection with the medical examination was devised, a complex coordinator was developed and tested in relation to success in flight training, and criticisms of certain visual tests were voiced. Flight surgeons rather than professional psychologists were chiefly responsible for the first three developments, while a psychologist, as well as medical men, had a hand in the last mentioned development."

Reviewing the early work in aviation psychology we see that the ground had been broken and problems had been clarified. However, these earlier beginnings have been criticized for (1) their emphasis on selection to the exclusion of the learning process and other functions affecting flight performance; (2) their neglect of job analysis as a means of determining the exact value of the task performance by pilots; (3) their failure to conduct research in the air; and (4) their failure to develop trustworthy methods for rating or measuring flight performance so that the value of tests in selecting aviators could be determined. Where tests had been used there had been too much dependence upon their "reasonableness," upon what is sometimes called face validity, and there had been a parallel failure to determine experimentally the actual value of these tests in selecting flyers.

To quote further:

"By 1941, when the United States entered World War II, a well-organized program of aeronautics research was under way, and there

* Prepared by Cdr. Alan D. Grinsted, MSC, USN.

were at least 100 psychologists who had obtained direct experience in such research. This development was largely traceable to the support given since 1939 to psychological research in aviation by a Federal agency, the Civil Aeronautics Authority (now called the Civil Aeronautics Administration).

"In the fall of 1939 this authority embarked on a program of training 10,000 civilian pilots, chiefly among the undergraduate personnel of American colleges and universities, as part of a wide-scale effort to develop the light plane industry by encouraging private flying. Through the efforts of its director of Research, Dean R. Brimhall, a fund was set aside for psychological research in the selection and training of civilian aircraft pilots. This fund, increased as the civilian pilot training program expanded, was allocated to the National Research Council, which established a Committee on Selection and Training of Aircraft Pilots to plan and supervise research. Included in this was an executive subcommittee of psychologists and representatives from aviation medicine, civilian flying associations, air arms of the services, and commercial air lines. . . .

"The research program of this committee naturally included the selection and classification of pilots. However, from the beginning, the importance of training problems was recognized, and attention directed at once towards the investigation of the learning processes and of other factors involved in the acquisition of pilot skill. Rating scale technique and lithographic and photographic methods of recording were developed, the aim being to procure reliable measures of pilot performance during flight. Problems of tension and fatigue, the effects and treatment of motion sicknesses, and similar maintenance problems were likewise investigated. Moreover, these problems were studied, not alone in the laboratory, but in the cockpit of the plane under actual flight conditions. . . . Such investigations produced significant findings which were employed in connection with the military effort during World War II."

The program thus described represented the first really comprehensive and systematic approach in this country to problems of aviation psychology. Not only was the scope broadened to embrace the training and maintenance of flyers as well as their selection; the program also stressed for the first time the need for reliable measures of flight performance, investigations under actual flight conditions, and experiments to determine the validity of tests of flight performance. There was an attempt to overcome these faults in the program launched in 1939, conducted by cooperating psychologists under the general direction of the Committee on Selection and Training of Aircraft Pilots.

To a large extent Navy aviation psychology originated in work sponsored by this committee as a part of this program. Many of the civilian investigators eventually accepted naval commissions, and the work expanded as the pressure of the war emergency increased. However, naval psychology, as related to medicine, was not limited to activities concerning aviation, as is apparent when Jenkins states as follows:

"More than 200 psychologists were commissioned under the auspices of the Bureau of Medicine and Surgery, divided approximately equally between programs in neuro-psychiatry and aviation psychology. . . . The program of commissioning psychologists was begun in the Navy as early as July of 1940, followed by calls to active duty in that same year."

At first a few psychologists had been procured for assignment to training facilities under the conviction that they could be of help in giving tests "and in other ways." The test program had been developed; the "other ways" represented the conviction that psychologists, since they dealt with human nature, must be able to do something besides administer tests. As indicated in the quotation above, they were used in two major programs and found important roles in both. We are here concerned primarily with psychology in aviation medicine, and no attempt will be made to review the work of those in the neuropsychiatric program. Nevertheless, the clinical aspects of the psychologists' contribution cannot be entirely ignored, for the aviation psychologist spent much of his time as a counselor to the student aviators, and his work in many ways supplemented that of the flight surgeon. In fact, in many activities shortage of medical personnel made it necessary that the services of the stu-

dent advisory officer, as the psychologist was often called, be utilized in functions that would otherwise have fallen to a neuropsychiatrist. Consequently, the psychologists who were first procured with the vaguely formulated idea that they could help with selection "and other things" had, by the end of the war, been assigned a fairly definite role in the program for training flight personnel, which role included some clinical counseling of individuals in addition to duties more specifically related to training problems and research.

In order to understand the role that the psychologist has played in aviation medicine, it is probably necessary to consider, at least briefly, the background of psychology as a science, and some of the problems it has had to face. In the first place it is young as sciences go. Eighty years ago there was as yet no such thing as a psychology laboratory. Psychology was, in both the academic and popular sense, a fit subject for armchair dreaming. Even today there are still some small colleges who teach something they call psychology in their philosophy departments. Psychology has only just succeeded in finding recognition as a science.

Then, in the second place, psychology has suffered from a certain unwanted popularity. Simply because it concerns itself with problems of human nature, everyone who has ever felt curious about his fellow humans feels justified in thinking of himself as a pschologist of a sort. Furthermore, this natural interest has been exploited by popular writers, fortunetellers, mind readers, and many others who have found profit is claiming a right to the title "psychologist." The loose use of the words "psychology" and "psychologist" has done much to confuse the average person regarding their true meaning.

The consequence of these problems has been that the scientific psychologist has been rather more inclined than he might otherwise have been to put heavy emphasis upon strict adherence to the scientific method. In addition, the very nature of his subject matter has been such as to cause him to analyze himself and his own methods. Knowing something of the frailties of human beings he has tended to be unusually skeptical of those who make generalizations about human data, even to the point of being skeptical about himself, his own observations, and his own results. He knows that no one individual can ever expect others to interpret the universe just as he does. He also knows that he can never assume that his interpretation is any more certain to be correct than that of another person unless he makes use of many and crucial checks on what he perceives. In order to avoid giving cause to any who might confuse him with the armchair theorist or the fortunetellers and others who make false claims to an understanding of their fellow humans, the scientific psychologist has disciplined himself rigorously in adherence to scientific procedure and has forged ahead in the shaping of tools and techniques for the accurate measurement and controlled manipulation of data concerning problems of human behavior.

Thus it is that in the relatively new and fast-growing field of aviation medicine psychologists have found a welcome. The clinically-trained man of medicine found his interest in and knowledge of human problems neatly supplemented by the trained psychologist's interest in and technique for inquiring into some of those problems. Psychologists who at first were procured to help administer tests and "other things" found themselves, by the end of World War II, working with problems in many fields. Their acceptance into the naval aviation medicine family was finally signalized by the creation of regular Navy billets for psychologists in 1947, and training in the scientific application of psychological techniques has become a regular part of the training of the naval flight surgeon.

WHAT IS SCIENTIFIC PSYCHOLOGY?

The movies and radio have created in the popular mind the idea that all a person needs to do to be a scientist is to don a white coat and stand behind a table covered with test tubes and beakers. Few people seem to take the time to try to analyze the meaning of the word *science* which is so commonly used and so often misused.

What is science? Is it a white coat? A set of instruments? A body of knowledge? Science is much more than these. It is, first and fore-

most, a way of searching for the truth. It is a method, a type of approach to problems, and it is fundamentally the same whether used by the butcher, the baker, the candlestick maker, the physicist, the physiologist, or the psychologist. It is a method of investigation, and he who uses that method is a scientist.

Science involves, first of all, the objective attitude. This attitude is that of the open mind. The scientist must train himself to view his data without bias or preconceived notions, and to concern himself more with the exactness of data and the validity of his conclusions than with any possible personal value so far as he is concerned. For the true scientist must be impersonal and skeptical, even toward himself.

The non-scientific observer often finds this a very hard attitude to maintain. When one is dealing with persons, it is difficult to be impersonal. And when you are one of those persons the difficulty is multiplied. The easy way is always to accept the traditional or popular notions. "Common sense" so often furnishes a "reasonable" answer! And yet "common sense" has led to many false answers and has long lulled mankind into complacent acceptance of ignorance that might easily have been dispelled by a little skepticism leading to experimentation. Folks might still be blaming malaria on the dampness of the night air if it weren't for a little healthy skepticism.

Yes, the scientist must dare to doubt the ready answers of tradition and ancient authority. He must have uppermost in his mind the questions, "What is the evidence? How do I know this to be true?"

In addition, he must also ask himself these questions about his own conclusions. He must be able to recognize valid evidence when he meets it and know how to remove the disguise from the phoney "facts" that sometimes slip by with the appearance of truth. In order to do this he cannot always trust his own observations. He knows that two people seeing the same thing often report quite differently on what they see. So, he doubts his own observations. That means that he is forced to resort to various techniques that will make it possible for others to check his results. He must objectify his data and, if possible, gather his information in such concrete form that no one can say, "That's just what *you* think."

Of course, objectivity is relative. A certain amount of subjective judgment is inevitable, if only in the interpretation of our objectively gathered data. In some psychological or physiological experimentation the subjective judgments play such an important role that it is necessary that the scientist compare many observations. His own observations will vary with themselves, observations between observers will vary, and variation will occur even in the conditions observed. The only answer is found in numerous observations systematically controlled.

Finally, the scientist must adhere to certain rules of the game. One of the rules is that he must be logical. Perhaps he need not have studied formal courses in logic, but if he assumes that all redheads make good pilots because he once knew a redhead who was a high-flyer, he is not likely to contribute much to the world of science. To be a scientist, a man must think clearly, state his problems in a meaningful way, and then follow the so-called scientific method. This procedure has four steps: First, there is the accumulation of existing data or evidence; second comes the classification of this evidence in orderly fashion; third, the scientist draws a generalization (and this is where the ancient philosopher used to stop, thinking that he had arrived at the truth; modern loose thinkers like to stop here, too—it often saves them from changing their opinions); and fourth, the scientist, recognizing his generalization as being only a hypothesis (a good guess), proceeds to put it to every conceivable test to discover its truth or determine its limitations. This last step is crucial. Without it there is no true science.

The way in which a scientist tests his hypotheses varies with the circumstances. The ideal method is the experiment in which quantitative measurements are obtained under conditions so carefully controlled that a repetition of the experiment in the same manner by another scientist can be expected to yield the same data.

Scientific method in aviation psychology is in no sense different from scientific method applied to aviation medicine as a whole. Actual experimentation is the ideal method of verifying our hypotheses, but is not always practi-

cable when dealing with human beings. Much successful experimentation has been done, especially in the sensory fields as they are affected by conditions of flight. Problems surrounding the states known to aviators as vertigo furnish a neat illustration of the kind of psychological experimentation that has been profitably carried on in the past and that is continuing. As a result of the strict application of scientifically controlled procedures, more and more light is being thrown into this no man's land of fears surrounding disorientation, autokinesis, and kindred perceptual confusions attendant upon the pilot "lost" in space.

The primary difficulty in any scientific approach to psychological problems has always been to find means of obtaining accurate measurement of the variables under consideration. How dizzy is a pilot after two slow rolls? As dizzy as the blonde next door? How can you tell? Or, how hot is a "hot pilot"? Can you figure a way to measure this kind of heat?

Well, there are plenty of measurements that we would like to get that are so far inaccessible. Nevertheless, much headway has been made in the measurement of many characteristics of the human individual who was considered a few decades ago to be beyond the reach of any scientific yardstick. Navy psychologists have not yet figured out how to measure accurately the feelings of a man who falls from a plane without a parachute, but by use of tests that have been developed, they can name the odds on a man's chances of passing flight training.

INDIVIDUAL DIFFERENCES

If the Navy receives delivery of a thousand new airplanes of a certain type we may be reasonably sure that they will be uniform in construction and ability to perform. But to find the pilots who are able to fly these planes with satisfactory and uniform degrees of skill presents a major problem. That identical machines vary in production when under different operators has long been recognized in industry. Folks differ by nature as well as training, and of two workers on the same job, one may be found two or three times as efficient and productive as the other. A job that is boring to one worker may prove satisfactory to another and too difficult for a third. Consequently, the industrial world is placing increasing emphasis on the placement of each individual on a job for which he is suited, both in ability and temperament. The Navy, likewise, has learned that many of the problems of aviation depend upon selection of the right man for the job, and probably nowhere has recognition of individual differences paid higher dividends.

The whole idea of scientific selection is based on the fact that no matter what characteristic of mankind we measure, the measurement obtained will be found to be distributed in the population according to a certain pattern. It doesn't matter whether we measure physical traits like height or thickness of toenails, mental characteristics like intelligence or ability to memorize telephone numbers, personality traits, emotional stability or what have you; the resulting measurements are always found to be distributed in the population in the same general way.

Suppose we have measured the heights of a large group of men. Now let us arrange the men in lines, standing all those of the same height in the same line. With these lines arranged in order of height, the short men on the left and the tall men on the right, the columns would form an arrangement somewhat like Figure 7-1.

If some measurement other than height had been obtained, the individuals would not fall in the same columns, but the pattern of the lines would be similar. As indicated, half the group falls in the middle range. These are the average or near-average individuals in regard to the trait measured. Measurements above and below this middle range are fewer and fewer, so that the lines become shorter and shorter as we move away from the average in either direction.

We can picture the same thing by drawing a smooth curved line, such as would include the contour of the figure above. In such a graph the height of the curve at any point would represent the number of times the various measurements plotted on a baseline were found to occur in the group measured. This is an example of the normal probability curve for

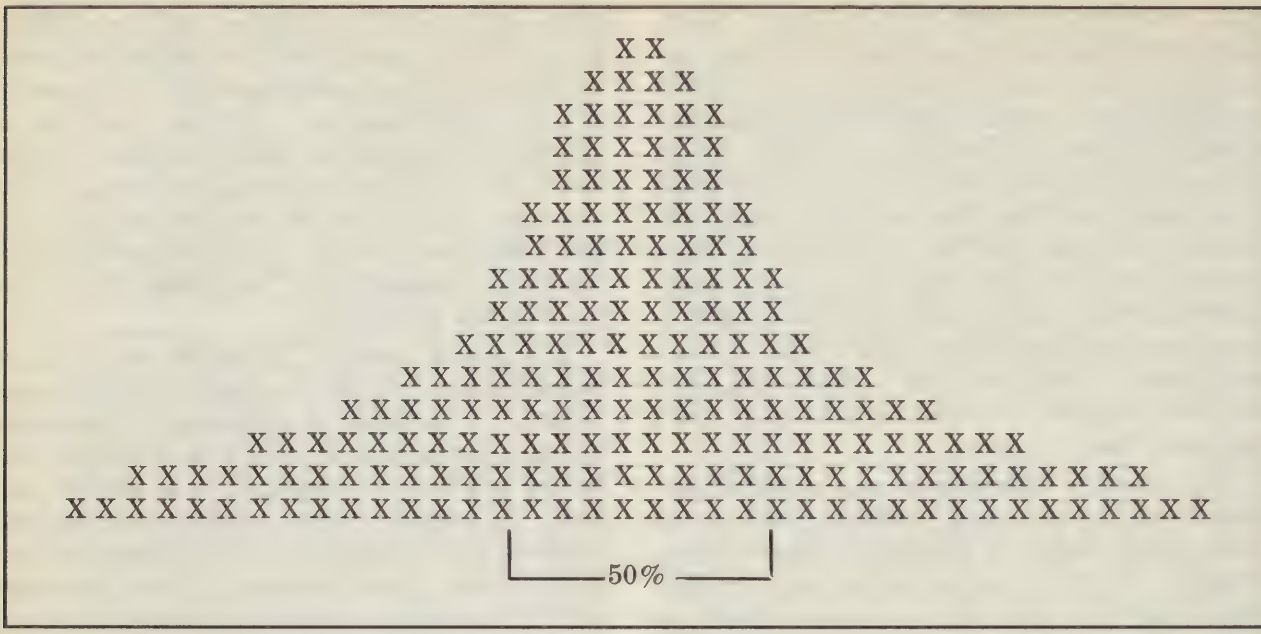


Figure 7-1.

individual differences. It is characterized by its bell shape, and is symmetrical about its center, which is the average or mean.

Such a distribution curve is of value in many ways. Most important perhaps, is the fact that it enables us to judge the importance of a measurement or score in relation to other measurements or scores. For example, if we find that a certain man in a gun factory can turn out 100 parts per hour, the information is relatively meaningless until we find that this is better than 9 out of 10 men do, which fact indicates his superiority.

Let us suppose that you need a crew of men to copy long lists of names and you have 100 men to choose from. In order to get those who can do the job the fastest, you have each write Wadek Gyzinski and time him as he writes. When you have timed all 100 men, you may well find yourself with a very confusing accumulation of figures.

In order to analyze such numerical data adequately, you will do well to systematize it in the form of a frequency distribution. With all of your time records converted to the nearest number of whole seconds, you might get something like Figure 7-1.

Score (Number of seconds required to write Wadek Gyzinski)	*Tallies* (Each tally represents one man who took the corresponding number of seconds to write Wadek Gyzinski)	*Frequency* (The number of men who took the corresponding number of seconds to write Wadek Gyzinski)
3	1	1
4	1111	4
5	~~1111~~ ~~1111~~ ~~1111~~ ~~1111~~ 1111	24
6	~~1111~~ ~~1111~~ ~~1111~~ ~~1111~~ ~~1111~~ ~~1111~~ ~~1111~~ 1	36
7	~~1111~~ ~~1111~~ ~~1111~~ ~~1111~~ ~~1111~~ 111	28
8	~~1111~~ 1	6
9	1	1
		N = 100

Such a frequency distribution makes it easy to draw a graph of the results, with the scores arranged along the horizontal axis (abscissa)

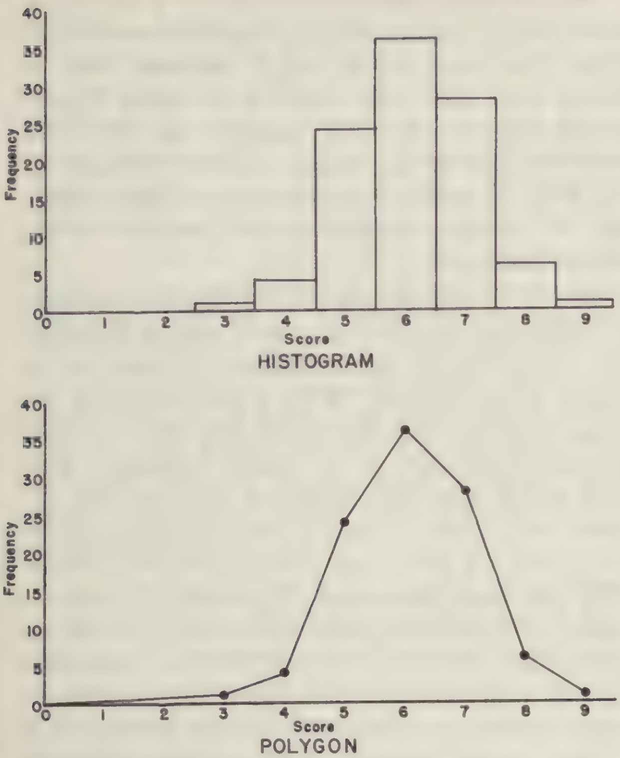


Figure 7-2.

and the frequency with which each score occurs indicated on the vertical axis (ordinate). In this case there are 100 subjects, so that the vertical axis gives us both the number and percentage of men for each score. A graph in terms of percentage is often useful.

If we had a large number of cases, our frequency polygon might be expected to approach the shape of a normal probability curve. Such curves are determined by so many factors that they are sometimes called curves of chance. Indeed, even the number of heads turned up when 10 coins are tossed many thousands of times will arrange themselves in approximate accordance with the normal probability curve or curve of chance. Of course, the perfect symmetry of the normal probability curve is never actually attained, although there may be a close approximation to it. Sometimes, on the other hand, the distribution is skewed; that is, the scores are more numerous above than below the peak of the curve or *vice versa*. The distribution is usually treated as normal in making computations, however, unless the skewness is extreme. Such extremely skewed distributions have a noticeable "tail" when pictured in a graph. This is because of a few atypically high or low scores. If unusually low scores occur at the left, the distribution is *negatively skewed;* if at the right the distribution is *positively skewed.* Our distribution above is not noticeably skewed.

Now suppose it is desirable to represent the above data in a sort of simple shorthand. Then a measure of central tendency will give the typical performance of the group. The measure of central tendency most often used is the *arithmetic mean* or common average. It is obtained by adding all the scores in the series and dividing by the number of scores. Thus, if we add all the scores made by the men writing Wadek Gyzinski, we find that it took the 100 men a total of 608 seconds, which gives us an arithmetic mean of 6.08 sec. In common parlance, it took the average man 6.08 seconds to write Wadek Gyzinski. This method of computing the mean can be used satisfactorily when there are only a few scores. However, a shorter method is available for computing the mean from large numbers of data grouped into frequency tables.

Another measure of central tendency is the *median.* When the measurements are arranged in order of size, the median is the point that divides the series of scores into two equal groups. It may be the middlemost case or it may be a score that lies half way between the two middlemost scores. The median of our distribution would be 6.58 seconds, which can also be computed from the frequency distribution. One other measure of central tendency occasionally used is the score occurring most frequently, and this is called the *mode* of the distribution. The mode of our distribution is six seconds. Distribution may also be bimodal, with two points of high frequency; or multimodal, with many such points.

Each of these measures of central tendency has its place. Wherever accuracy is important, and if it is not misleading, the mean should be used. Extreme scores, however, may be such as to render the mean a poor measure of central tendency. For example, if in our illustra-

tion mentioned above, one man with an emotional disturbance kept trying for three hours before he succeeded in writing Wadek Gyzinski, inclusion of his time in our calculations would give us a mean of nearly 8 seconds, a grossly misrepresentative figure. On the other hand, the median would not have been greatly affected by such an extreme case. The median is usually more representative than the mean when there are few scores in the distribution, and particularly when atypical measures are included. It also has the advantage that it is easily computed. The mode also can be arrived at easily by inspection of the frequency distribution or a graph, but it is a crude measure, useful as a rule only for making a quick appraisal of the central tendency of the distribution.

Unfortunately, it is often not enough that we know the central tendency of a distribution. Two distributions may have exactly the same mean and yet be very different. A much clearer picture of a distribution is obtained when the average is stated along with some measure of dispersion or scatter of the measures about that average. For example, in our illustration above, if we know only that the average man took 6.08 seconds to write Wadek Gyzinski, we do not know whether all 100 men took the same length of time or to what extent some were faster than others.

The most easily understood measure of such variability is the range of distribution, which is simply the distance between the highest and lowest score (six seconds in our illustration). Where statistical detail is desired, however, the range tells too little about the pattern of the distributed scores.

Another and infrequently used measure of variability is the mean deviation or average deviation which is obtained by calculating the amount by which each score deviates from the mean, then adding all the deviations, and finding their average. There are mathematical objections to the use of this measure.

The standard deviation is the most commonly used and most accurate. It is obtained by finding the square root of the mean of the squared deviations taken from the arithmetic mean of the distribution. In large distributions the necessary processes involved here would be long and tedious. However, simpler, short-cut methods have been evolved for arriving at the same answer. (The probable error is a similar measure being used less and less).

The standard deviation (SD) or σ tells us to what extent the scores in a distribution deviate from the mean; or to put it another way, it shows how near the mean is to being typical of all the scores. The smaller the S.D., the more typical is the mean, because the size of the S. D. is reduced as the scores cluster closer, and it becomes larger as the scatter of the scores increases.

The S. D. also serves another useful purpose; it furnishes us with a means of stating the position of any given measurement or score in relation to its fellows. With a knowledge of the mean, we can say that such and such a score is above average or is below average. But, how much? A knowledge of nothing but the mean will enable us to tell almost nothing about the extent of deviation of any particular score. The standard deviation furnishes us with a scale for measuring such deviation through the calculation of what are known as *standard scores* (also called z-scores). The standard score is simply a statement of the deviation of a given score from the mean of the distribution expressed in S. D. units. If, for example, a score of 165 occurs in a distribution with a mean of 150 and a standard deviation of 30, this score may be said to fall 0.5 units above the mean. This (0.5) is, then, the standard score equivalent for the "raw" score of 165, and is calculated simply by subtracting algebraically the mean from the raw score and dividing by the standard deviation. If the raw score is below the mean, this is indicated by the use of a minus sign.

The use of the z-score enables us not only to state more clearly the position of any score within a distribution, but also makes it possible for us to compare a man's standing in various measures and equitably combine separate measures into a composite score, which combination would have been statistically undesirable, using raw scores alone. The z-score also makes it possible for us to make a more nearly accurate comparison between the performances of two men where the tests for the two men are similar but not the same. This latter use is sometimes practically necessary al-

though inadvisable, and can be employed only where the tests have given to comparable populations. For example, we may wish to know which of two men is the faster on a job of assembling small gun parts, but while they do similar assembly work, they work in different departments and the jobs they do are not identical. In such a case, we may know that Jones produces 57 units per hour on his job and Smith produces 79 units per hour on a slightly different type of assembly job. Since the jobs are not just the same, we cannot assume that Smith is the faster worker. Here, then, z-scores may prove helpful. If we know the average rate of production on both jobs and the standard deviations, we can calculate the z-scores, and we may find that Smith's standard score is only 1.2, whereas Jone's score is 2.0, indicating that in comparison to others doing similar work, Jones is the faster. The z-score, therefore, has many important uses.

It is impossible here to go into great detail concerning statistical procedure in use in aviation psychology today, but some understanding of the concepts employed may be gathered from the discussion presented here.

SELECTION*

Two men want to enlist in the Navy. They are both healthy looking 18-year-olds, both enthusiastic about leading the Navy life. They both have good ears, good eyes, good teeth, and good hearts. But when they take one of the Navy's paper-and-pencil tests, one passes, one fails. The one who fails is turned down. He cannot get into the Navy because he cannot answer a few questions on a sheet of paper.

Twenty-five years ago this sort of procedure would have seemed the height of foolishness to many seasoned fighting men. Even today there are people to whom paper and pencil tests constitute adequate cause for a raise in blood pressure. But such tests are now standard Navy procedure and will likely remain so. Psychological tests have proved their usefulness. The fact that a man fails to make certain marks at the right time at the right place on the right sheet of paper means that he will not be accepted for general Navy training.

What sort of justification is there for such a procedure? How does it make sense that we turn down a likely looking future navigator or gunner or radioman or aviator because he can't answer a few questions?

We have seen how men differ. Even if all men were born equal, they would get over it almost immediately. Every man differs from every other man. Every man has his own pattern of abilities, aptitudes and traits. That basic fact is fifty percent of the justification for selection.

The other half of the justification is found in the differences among jobs. Jobs differ among themselves probably just as much as do individuals. Each job demands its particular sort of muscular movements, its particular sort of sensory keenness, of perception, of coordination, of endurance, of intelligence.

Modern industry and modern warfare are highly specialized activities. Neither in the armed forces nor in civilian production can we gain personnel efficiency without doing a decent job of finding specialized men to do these specialized jobs. Perhaps any man can be taught to operate sonar, to make precise judgments about the time, pitch and loudness of sounds, to tell the differences between neutral flounders and enemy cruisers. But when one man is gifted with unusual ears, and this job can use unusual ears, it is wasteful not to get the job and the ears together. The man with the high quality ears will be likely to learn sonar skills sooner, likely to out-perform the man who lacks the basic auditory abilities.

Once you have decided on selection, your selection pays off in proportion to your choosiness. If you have a large number of applicants and a selection procedure that is known to measure their potential usefulness for the job, the way to get the best performance, obviously enough, is to select only the very best men. The AAF conducted an unusual experiment during the war to show just how this economic factor works.**

The AAF had a systematic and extensive program for selecting pilots. Before a man was

* This section has been condensed and adapted from *Naval Leadership, Book II: Psychology for Naval Leaders*, Ch. VI, U.S. Government Printing Office, Washington, 1948.

** From a report entitled *Stanines, selection and classification for air crew duty* prepared by: The Aviation Psychology Program, Office of the Air Surgeon, Headquarters, Army Air Forces.

accepted for training he had to pass medical, psychiatric, and psychological examinations. To check on the economy and effectiveness of this program after it had been set up, the AAF people let one thousand unscreened youngsters into their training program. This group had to meet the minimal medical requirements, but otherwise the group was composed merely of a thousand young men who wanted to fly. These aspirants were mixed in with the normal AAF trainees and given the same course of preparation for flying. Careful records were kept, and this group was compared with groups that had been given the works — medical, psychiatric, and psychological examinations — and who had been allowed to go on to flight training only if they met certain standards.

A good number of the unselected men succeeded in winning their wings. But their training was expensive business. The results showed that for each hundred of them who got through training, 297 of them fell by the wayside. So, to end up with 100 pilots, 397 men had to be entered into training. These men dropped out at various stages. Let's say the average washout was dropped halfway through his training, and let us suppose that it costs $25,000 to train a pilot. On the basis of these assumptions, the cost of producing 100 pilots from this unselected group would be $6,202,500. Each pilot from this group would cost, then, $62,125.

A second group was admitted to flight training on the basis of (1) passing a psychiatric check, (2) making slightly below average scores on the AAF qualifying exam, and (3) making average scores on the AAF battery of aviation-selection tests. The results for this group show that for every 100 successes there were only 102 failures. To get 100 pilots, 202 men must be started in training. Using the above assumptions about cost, the total expenditure for 100 pilots in this group was $3,775,000. This gives a figure of $37,750 per pilot.

A third group was more highly selected. They (a) passed the psychiatric exam, (b) obtained a slightly below average score on the AAF qualifying exam, and (c) obtained *better* than average scores on the pilot-selection examination. The results on such a group show that for each hundred men getting their wings only 56 wash out. This means that the training of a hundred pilots costs $3,200,000. or $32,000 a pilot. This represents a hypothetical saving, as compared with the first groups, of $3,012,500 per hundred pilots, or $30,125 per pilot. When you multiply the latter figure by the number of pilots in the AAF during the war, the total is something quite impressive even in an age when a billion dollars does not particularly impress the taxpayer.

MEASURING MAN'S ABILITIES

There have been many techniques for "knowing" men. Obviously enough, one good way to see whether a man can do a job is to watch him do it for a few years. His performance will give the best evidence as to what his eventual performance will be like. But this procedure of getting a sample of work has serious drawbacks. In the first place it takes time. In the second place, it is often dangerous and expensive to let an inexperienced man try his hand at running an intricate machine — like a $100,000 airplane or a 16-inch gun. In the third place, the sample of work tells only about present performance. It does not give clear information about how good the man will be after a period of training.

We need a procedure that (a) does not take much time, (b) that is not expensive or dangerous, and (c) that enables us to predict future performance.

Aptitude tests, now available in many forms and for many purposes, meet all three criteria for a good selection procedure. They do not take much time. They are not dangerous (except when badly administered or interpreted). They are economical. And, when properly used, they allow a prediction about what we are most interested in — the future.

At the beginning of World War II a group of psychologists undertook the job of building tests that would select naval aviators. The first step these men took was that of learning at first hand what a naval aviator had to do. They investigated the cadet's ground school courses, poked into the things the aviator needs to know about navigation, communication, aerology and engineering. They studied the flyer's move-

ments while in a plane, observing the number and variety of his coordinations, the number and variety of things he has to attend to, and how rapidly he must learn new ideas and new skills.

All this intimate knowledge of the job served to give the psychologists hunches about what sort of measurable abilities and interests might differentiate — in advance — between the successful and the unsuccessful flight trainees. When hundreds of such hunches are combined with information gathered in previous research and are combined with the ideas of experienced pilots, the basic raw material of the test is at hand.

Suppose our hunches led us to think that the following two questions would help in selecting men for aviation training:

1. Which one of the following planes has two motors?

   a. The spitfire.
   b. The Hurricane.
   c. The Lightning.
   d. The Typhoon.
   e. The Kittyhawk.

2. The speed of outboard motors is often controlled by:

   a. Changing the pitch of the propeller blades.
   b. Advancing or retarding the spark.
   c. Changing the angle of the propeller on the stern post.
   d. Raising or lowering the propeller.
   e. Loosening or tightening a brake on the flywheel.

The correct answer to the first question is "c." The correct answer for the second is "b." Our problem now is to see, by actual experimental trial, whether these and hundreds of similar questions are answered any more correctly by successful then by unsuccessful aviators. So we give our hundreds of questions to a thousand applicants for flight training. We record their answers and file the papers away for a few months. When flight training is complete, let's say that five hundred of our cadets had won their wings and five hundred had washed out into gunnery school at Great Lakes. We now have a way to see which of our questions have something to do with aptitude for flying. If the successful flyers answer a question one way and the washouts answer it another, the question is clearly related in some way to a man's chances of winning his wings.

Take question No. 1, above. Let us say that of the 500 who passed flight training, 320 answered the question correctly, and of the 500 who failed, only 102 knew the right answer. The question looks like a good one to include in the test. If you bet that a man who knows the answer will get his wings, it looks like you have 320 chances out of 500 of winning. The man who does not know the answer is a longer shot. He has, if the odds hold up, only 102 chances out of 500 of winning his wings.

Not all questions, based on hunches, turn out so fortunately. Let's suppose that of our 500 who passed flight training 420 got the question right, and that of the 500 that failed, 415 knew the answer to the question. The question obviously does not do much to distinguish between passers and failers. We forget that question. It will do us no good at all.

Just as with specific questions, the whole test must be put through its paces before we know how much good it will do us. Do people who make high scores in the test perform better on the job than do people who make low scores? Suppose we were required to find tests that would pick good machinists, that would tell us in advance the chances that any given man will do well in the machinists' training and at machinists' work. We may have to create our own test or tests for this job of selection. We would save a good deal of time, however, if we could use tests already constructed. The procedure would be to select available tests which seem likely to have something to do with being a good machinist. We may select a test of intelligence, a test of mechanical aptitude and a test of manual dexterity. Our hunches may say that these tests get at abilities the machinist needs. But before anyone can know whether these tests work, the tests must pass a test. Are scores on intelligence tests related to performance as a machinist? Does manual dexterity, as tested by our test, relate to the machinist's performance? There is no way to answer these questions except to have a good look. We give our tests to a group of potential machinists, file the scores away, come back a year or so later, measure the machinists' performance,

and compare the test scores with performance. If good performers got higher scores on any or all of our tests than did the poor performers, we have a potentially useful procedure for selecting machinists.

VALIDITY

When we talk about the relation between performance on a test and performance on a job, we are talking about the validity of the test. However good our items appear to be, however much sense the test or the battery of tests seem to make, we must always ask and answer the hardheaded questions, "Does the test do what it is supposed to do?" *The validity of a test is a statement of the degree to which a test predicts (or measures) what it is supposed to predict or measure.*

The validity of a test (or battery of tests), the extent to which it does what it is supposed to do—is measured in terms of the relation between scores on the test and performance on the job. If all men who make high scores on a mechanical aptitude test have good records of performance as machinists, and low scores go with poor performance, the test obviously has, for the purpose of selecting machinists, good validity. If high scoring men and low scoring men do equally well on the job, the test has no validity and hence is useless for this sort of selection.

It is important for many reasons to know precisely *how* valid a test is. It is necessary to determine the exact relation between scores on the test and actual performance on the job. This means we must not only score the test quantitatively, but we must find some way of measuring performance. The latter problem is often a difficult one. Human performance is hard to measure, particularly on intricate jobs. The problem of measuring performance is the problem you will hear test-constructing people refer to as the "problem of criteria." *There must be a criterion of performance before we can measure the relation between our tests and what our test tests.* If we want to see whether or not we have picked good machinists or gunners, we must have a way of recognizing a good machinist or gunner when we see one. And it would be better if we could measure precisely how good. Often it is necessary to say a machinist is good, if he received high grades during training or if his supervisors on the job rate him as good. Sometimes we have to say a man is good if he passes his training course. In selecting naval aviators, for example, the good men were defined as those who passed training, the bad as those who failed. The aviation selection tests were evaluated in terms of their ability to pick men who passed and to reject men who failed in flight training. These tests were validated against a pass-fail criterion. Whether the criterion is a matter of ratings by competent judges, of grades received in training, of precise measurement of performance, or of over-all passing or failing in training, there must be a sound criterion or we will never be able to tell whether the test is doing the job.

The relation between test scores and the criterion is stated in terms of coefficients of correlation (or coefficients of validity, when referring specifically to problems of validation).

CORRELATION

There are several sorts of coefficients of correlation. But the principle is essentially the same for them all and can be illustrated by the simple rank-order correlation coefficient. Suppose fifty people took a college entrance examination. And suppose the college grades for these fifty were also available. To obtain a measure of the relation between the test and the performance you would first rank the individuals from 1 to 50 on the basis of their test scores, with the highest scorer being given a rank of 1; the second highest, 2; the third highest, 3; and so on. Then you can compare the rank of each individual in one list with his rank in the other. Now, if it turns out that the man who scores first on the test also scores first in grades, that the man who scores second on the test scores second on grades, and so on throughout, a perfect correspondence of rank maintaining for each person, we get a perfect positive correlation. If we were sure that such a correlation were not accidental, we could then predict from the test exactly what a man's grade standing would be.

If there were a perfect reversal of ranks, with the first man on one being fiftieth on the

other, the second man on one being forty-ninth on the other and so on through the list, we would have a perfect negative correlation. A high score on the test would always mean a correspondingly low score in grades. The prediction would still be perfect but with a negative sign.

Such perfect correlations (expressed as coefficients of plus 1.00 or minus 1.00) rarely happen. It is much more likely that the man who ranks first on the scholastic test would be near the top in academic grades, and that the man who scores at the bottom on the test would be near the bottom in grades. By some fairly simple computations, based on the differences in rank for each individual, it is possible to reach a precise numerical description of the relatedness of the test scores and the grades. These coefficients of correlation are expressed in plus or minus decimals falling somewhere between plus 1.00 and minus 1.00. A coefficient of .90 would indicate a high degree of relatedness, a good chance of predicting grades from test results. A coefficient of .60 would indicate a sizable relation, with definite but limited prediction. A coefficient around zero would mean that the test and grades have no relation and there is no way of predicting from the test what the man will do in the classroom.

In actual experience with aptitude tests, a validity coefficient of .30 sometimes means the test can be useful. But the usefulness of the test increases as its validity goes up. A validity coefficient of .60 is considered good, one of .80 or above is generally regarded as excellent.

There are many tests now in use which are still essentially unvalidated. Some have been validated against doubtful criteria. Often it is possible to defend unsatisfactory validated tests on the grounds that they are at least better than unguided intuitions. But we can never be certain a test will do its job unless we have precise figures concerning its validity.

THE VARIETY OF TESTS

In the last 25 years psychologists have constructed a wide variety of tests for a wide variety of purposes. There are a large number of intelligence tests; there are mechanical, musical, clerical, scientific and scholastic aptitude tests; there are dexterity tests and tests of motor function; there are personality tests and interest tests. When confronted with the assignment of selecting men for a specific job, the psychologist can often use a group of tests already available. For any specific job, however, he must know in advance the precise relation between scores on any test he uses and performance in the job he is interested in. He can gain this knowledge only through a thorough investigation of the validity of the test for his particular criterion. It is not possible to know how any test or battery of tests will work in a particular job of selection until the tests are tried out specifically in that job.

THE ACTUARIAL NATURE OF SELECTION TESTS

We have seen that a psychometric selection program cannot function unless there are more applicants for jobs than there are jobs. Tests always select from among. We saw also that tests generally select some men who are poor, who will fail, and eliminate some who would do well at the job. This is just another way of saying that no test or battery of tests has perfect validity. But usable tests have known validity. That means that we know when we use a test what betting odds we are fooling with. We know, given the test's coefficient of validity, that, say, of the thousand men who make this particular score, 840 will give satisfactory performance on the job. And we know that of the thousand that score below a certain minimum, only 220 will perform satisfactorily on the job. Given such information we would have no doubt about which thousand we would hire or accept for enlistment or send to a special school. But test results do not give us the basis for making precise prediction about the single individual. Psychometric methods are actuarial methods.

The insurance company never knows when any given policy-holder will die and become a drain on the company treasury. But the insurance company still makes money by knowing pretty precisely the life expectancy of all men, say, 25 years of age. They can bet that a certain small percentage will die this year, a certain percentage 10 years from now, a certain percentage 50 years from now. They hope

any new policy holder will live to grandfatherly health, but they cannot predict anything about him except his chances. He has so many chances in one hundred of living to be 80. Psychometric tests work the same way. The individual who scores at a certain level on a certain test has, as far as we can tell, seventy chances out of a hundred of succeeding at the job. He has thirty chances out of a hundred of failing. That is all the test can tell us. If we knew all about the man, we might be able to predict with complete certainty what he will do. But tests are not yet that good.

The actuarial nature of tests means that the man who interprets tests must not be surprised if tests make errors. And the administrator should not bet on any individual beyond the limits of safety indicated by the test. No test wins all the time. But in the long run and with large numbers, tests with a satisfactory validity will pay off handsomely.

NAVAL AVIATION CADET SELECTION TESTS

There are now three tests in use for selecting cadets in naval aviation. These tests were introduced in the first place only after it had been demonstrated that they would consistently and reliably differentiate between those who ultimately passed and those who ultimately failed in naval aviation training. These tests now in use represent the most effective combination remaining of more than forty that were tried out. Each test was given to a large number of applicants, the results not being used to select in this case. Then the scores were kept in "cold storage" until those tested had either passed or failed flight training. Then the tests were checked against actual performance in terms of pass-fail data, and were retained for further study only when they significantly differentiated passers from failers and did not duplicate other promising tests. The three tests now in use were finally retained after a series of cross-checks had eliminated all the rest.

Such tests are of no value unless information concerning their content and the manner of scoring them are kept inviolate. Their value is also diminished when they are used in a manner that deviates from that employed during the original standardization process. For these reasons the responsibility for the custody of these tests and for their proper administration according to prescribed procedures rests in the hands of the flight surgeon or aviation medical examiner.

These tests were standardized in terms of the relative percentages of men failing in flight training at each score level, and figure 7-3 shows how some of this original data for two of the tests shaped up. Since then, the Aviation Psychology Branch of BuMed has maintained continuous surveys of the effectiveness of these tests, measured in these terms.

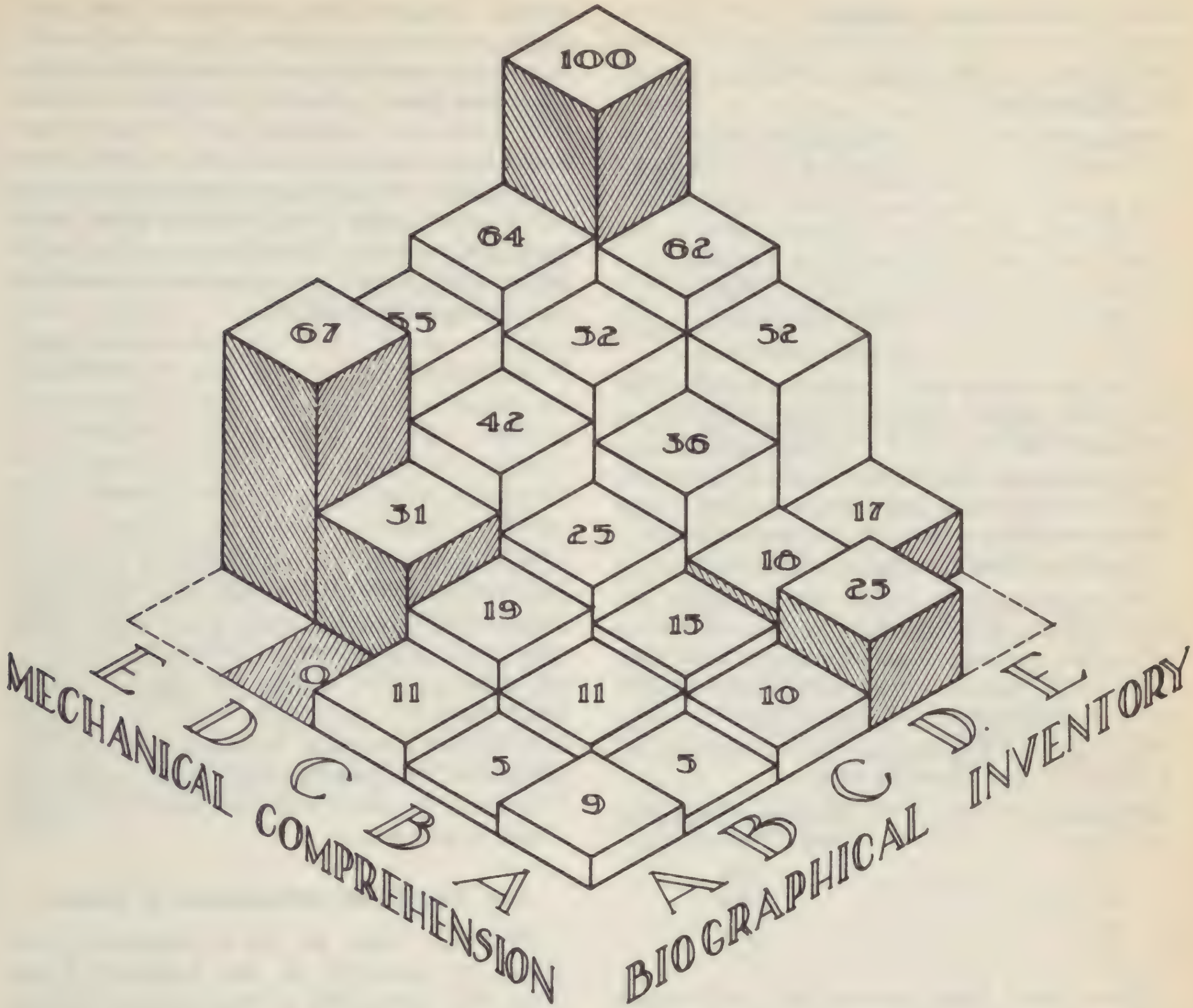
THE FLIGHT APTITUDE RATING

This is computed, according to a simple formula, from the combined scores on the three tests. The Flight Aptitude Rating (FAR) indicates the probability that a cadet having a given score-combination will ultimately pass the flight training course and be designated as naval aviator. These probabilities are stated in the following table, which is based upon long-term studies of large groups of entrants with an over-all attrition rate of about 30 percent:

FAR	*Percent Actually Failing in Training*
A	0-6%
A—	7-12%
B	13-18%
B—	19-24%
C	25-31%
C—	32-37%
D	38-43%
D—	44-49%
E	50% or more

THE AVIATION CLASSIFICATION TEST

This is essentially a test of general intelligence, worded to have a Navy flavor. Men who score low on this test tend to have serious difficulty in understanding complicated instructions or orders. The test is especially suited to the prediction of success in *ground school.* For example, in one group of 5,408 men who went through training in 1943-44, 5.6 percent failed in ground school. Most of these failures were men who had scored low in the Aviation Classification Test. The following table shows the percentage of each letter-grade group which failed in ground school:



PERCENTAGE OF FAILURES FOR B. I. AND M.C.T. COMBINATIONS

THIS CHART IS BASED ON 3294 CASES WHERE TESTS WERE NOT USED IN THE ORIGINAL SELECTION

SHADING INDICATES THAT THE PERCENTAGE OF FAILURES IN THAT CELL IS NOT STATISTICALLY RELIABLE

NOVEMBER 1, 1942 D.W.F - W.A.B.

Figure 7-3.

ACT Letter Grade	*Percent Failing In Ground School*
A	0%
B	1%
C	5%
D	14%
E	21%

THE MECHANICAL COMPREHENSION TEST

This test (the MCT) deals with the ability to handle the familiar, simple mechanical concepts of everyday life. Scores on this test have been found consistently to bear a direct and positive relationship to ultimate success or failure in flight training. For example, a tabu-

lation involving the records of 7,685 cadets, shows that for each letter-grade, the following percentages failed in flight training for any and all reasons:

MCT Letter Grade	*Perecentage Failing Flight Training for any Reason*
A	27%
B	36%
C	47%
D	62%
E	(Not admitted to flight training)

The table shows that a man scoring D on the MCT was more than *twice* as likely to be dropped from the pilot training course as a man scoring A. Notice was taken of this fact, and directives were later issued to reject men who scored D as well as those who scored E.

The above table gave figures on attrition in the pilot training course for *all reasons,* including flight failure, ground school failure, disciplinary action, or other causes. The selective value of the MCT becomes even more marked, however, if consideration is given only to those men who were dropped for flight failure. This is shown in the following table:

MCT Letter Grade	*Percentage Dropped for Flight Failure Only*
A	7%
B	14%
C	19%
D	30%

Thus, when flight failures only are considered, a man who scores D on the MCT is more than *four times* as likely to wash out as a man who makes an A.

THE BIOGRAPHICAL INVENTORY

Flight surgeons have long sought to appraise a candidate's personal history, interests, and attitudes in attempting to predict his probable performance as a pilot. The Biographical Inventory, based upon statistical analyses of thousands of pilot records, does with mathematical precision what the flight surgeon sought to accomplish on the basis of professional skill, experience, and intuition.

The Biographical Inventory is a non-time-limit questionnaire, containing questions on the applicant's personal history, attitudes, and interests. Research has determined that each scored answer bears a quantitative relationship to ultimate passing or failing in flight training. No single item is heavily weighted. Certain total patterns of response have, however, been found to be associated with high washout rates in training, while others normally accompany low washout rates. The following table, based upon the records of 7,744 men starting training in 1943, shows the actual percentage failing at each letter-grade:

BI Letter Grade	*Percentage Failing in Training*
A	29%
B	33%
C	41%
D	50%
E	58%

Test standards can be raised or lowered—with known effects—to comply with the supply-and-demand situation at any given time. When applicants are plentiful and billets are few, the passing score can be set high enough to admit only the very best risks. If it should ever become necessary to admit almost all the applicants, the passing score could be lowered to a point at which only the very worst risks would be eliminated.

TEST SCORES AND PERFORMANCE IN COMBAT

The tests were set up to accomplish one thing—to designate at the Selection Board those men most likely to wash out in training. The tables given show that the tests accomplish this in reliable fashion. They make it possible for the Navy to train more men in less time than would be possible in dealing with unselected groups. Computations show that the savings run into millions of dollars and, possibly more important in wartime, into many thousands of hours of training time.

While this situation was favorable, it still left one major question unanswered. It was at least theoretically possible that, by selecting men who would do well in *training,* the Navy was tending to select docile, well-behaved men who would not be outstanding in *combat.* Put in other words, there was a theoretical possibility that the tests, while *positively* related to performance in training, were more or less

negatively related to performance in combat. The answer could be obtained only by getting appraisals of combat performance on some hundreds or thousands of men for whom test-scores were available.

In 1944, DCNO (Air), in collaboration with Chief BuMed, made it possible for the Aviation Psychology Branch to send specialists into the advanced areas to obtain individual combat appraisals. By the end of the war, approximately 6,000 individual appraisals had been obtained from pilots in the war zones. While a detailed description of this work is not in order here, it may be said that a review of these records offers assurance that the use of the FAR in selecting pilots does not reject undue proportions of good combat men when it designates men who will do well in training. Indeed, while the difference does not meet conventional standards of statistical significance, there is a slight tendency for men rated as *high* in combat performance to make higher FAR's than men rated *low* in combat. Furthermore, it has been established that the use of the tests, including possible rescoring of the BI, can be made to increase the proportion of good combat pilots and reduce the proportion of poor combat pilots.

BIBLIOGRAPHY

1. *An Historical Introduction to Aviation Psychology.* Prepared by National Research Council Committee on Selection and Training of Aircraft Pilots. Report No. 4. Washington, D. C. Division of Research, Civil Aeronautics Administration, 1942.

2. Bingham, W. V. S., *Aptitudes and Aptitude Testing.* New York. Harpers and Brothers, 1937.

3. *Dictionary of Occupational Titles, Part I, Definition of Titles.* Prepared by United States Employment Service, Washington: U. S. Government Printing Office, 1939.

4. Hull, C. L., *Aptitude Testing.* Yonkers-on-Hudson. World Book Co., 1928.

5. Jenkins, John G., *Naval Aviation Psychology.* I. The Field Service Organization. *Psychological Bulletin,* 1945, 42(9), 632.

6. Maier, Norman R. F. *Psychology in Industry.* Boston: Houghton Mifflin Company, 1946.

7. Munn, Norman L. *Psychology, the Fundamentals of Human Adjustment.* Boston: Houghton, Mifflin Company, 1946.

8. Peatman, J. G. *Descriptive and Sampling Statistics.* New York: Harpers & Brothers, 1947.

9. Tiffin, Joseph. *Industrial Psychology.* New York. Prentice-Hall, 1946.

10. Tinker, Miles A. *Introduction to Methods in Experimental Psychology,* (2nd Edition). New York: D. Appleton-Century Company, 1947. (Chapters 1, 3, 4, 15, 21).

11. Viteles, M. S. *Industrial Psychology.* New York: W. W. Norton & Co., Inc., 1932.

CHAPTER 8

THE PSYCHOLOGY OF ADJUSTMENT *

"Adjust or die" is the first law of life. All organisms, from amoeba to man, are constantly busy internally and externally adjusting to the needs of the moment. The only organism that is not adjusting is the dead organism, for the processes of life are the processes of adjustment.

Every medical officer has been impressed with the need for constant adjustment on the biological level. The fact that the organism is also constantly adjusting psychologically is not always so apparent. The purpose of this chapter is to point out the nature of these processes insofar as modern science has made that possible.

THE NATURE OF HUMAN NATURE

Science and its matter-of-fact methods have only very recently been turned to a study of human behavior. The results of the scientific approach to the doings of people have led to what may be called an enlightened confusion. Scientists are not yet agreed about the best way to explain human behavior. But every day the ability to understand and predict man is increasing. And scientists strongly agree that we will understand better and predict more precisely only if we adhere to two basic scientific principles: (1) *behavior is caused* and, related; and (2) behavior is to be accounted for in terms of *natural causes.*

Scientists insist that human behavior makes sense. Behavior happens because things *make* it happen. Behavior is never an accidental, wayward, inexplicable process. It is amenable to cause-and-effect analysis. Although what people do may seem mysterious and adventitious, their actions are always caused and hence are ultimately predictable.

SCIENTIFIC EXPLANATIONS

The scientist accounts for what he observes in terms of *scientific constructs.* All the scientist can see is facts. He never sees an explanation. He observes facts and *creates* explanations. He creates a picture in his head of the processes going on behind the events he observes. If a man were unable to open a watch to see what went on inside, but could observe only the movement of the hands, the response to winding and the ticking, he would soon create for himself some picture of what the entrails of the watch were like. If he observed the watch long enough and under enough different conditions he could come out with a construct, a picture, of the dynamics of the watch. The construct, if it accounted for all the behavior of the watch and if it were the simplest possible explanation, would be accepted as an explanation of the watch's behavior.

In explaining human behavior, the same process takes place. The psychologist observes what people do and creates constructs to account for observed events. His main construct is the construct of *need.*

NEED-CONSTRUCTS

If you observe closely the behavior of a friend along about 1130 or 1200 of a typical day, you will probably note something like this: he becomes increasingly restless; the subject of food becomes of more and more conversa-

* Prepared by Cdr. Alan D. Grinsted, MSC, USN.

This chapter, with the exception of the last section, has been condensed and adapted from *Naval Leadership, Book II: Psychology for Naval Leaders,* Chs. I, III, IV; U.S. Government Printing Office, Washington, 1948.

tional interest; incidental things around him remind him of something to eat; and sooner or later he will make overt and direct movements toward the place food is to be found. You will conclude, with easy influence, that he is hungry.

You haven't seen his hunger. You've seen nothing but behavior. You read a need into your friend. You use a *construct* to explain his behavior. This construct is a picture in your head—a picture of processes going on behind the behavior you see.

The need in this case stands for some complicated and unobserved goings-on in the viscera of your friend. You the observer, create the notion hunger to stand for these background processes. If you say your friend has a sex need, or a need to dominate, or a need for social status, what you are doing is imagining something to go behind behavior. And you use this something, this construct, to explain his behavior.

No one ever saw hunger or thirst or gregariousness or any other need. All any one can see in looking at people is people's behavior.

Sometimes we are successful, through the use of special instruments, in seeing some of the physiological or neurological processes that lead up to overt behavior and in such cases (hunger) we can be quite comfortable about using the need-word. We feel we are on solid ground. The word hunger stands for certain fairly well-known physiological processes.

But sometimes we have no detailed information as to what processes may be behind behavior. In the case of gregariousness, for example, no one has ever found a muscular contraction or a pattern in the nervous system that can serve as the basis for the apparent need to be with people. Some people still go on behaving, however, as if they needed to be with people. In the case of hunger, the internal tensions lead to overt behavior, which leads to the taking aboard of food, which quiets down the internal tensions. In the case of gregariousness, a man may behave *as if* he had a similar built-in tension. He may be restless if he is not around people. Once there, he gives some evidence of feeling better. So we endow him with a need to be with people. A gregarious need is something he acts as if he must have. If we can predict his behavior tomorrow and next month by assuming he has a need to be with people, then the construct is a good one. It serves a useful purpose.

Since no one ever saw a need, and since needs are products of the mind of the man who needs something to account for the behavior of his fellows, the making of need-constructs is anybody's business. The layman makes up constructs and uses them to account for his own and other people's behavior. He explains inexplicable behavior in terms of God or stupidity or astrological disharmonics or bad luck or accident or evil spirits. The psychologists do some better, but even among psychologists there is no complete agreement as to what are the most useful constructs to use in making sense out of behavior. But as psychology has grown in age and stature, the continual process of experimentation, observation, and thought has distilled a group of constructs widely agreed upon as useful conceptual tools for thinking about human behavior.

DEFINITION OF NEED

Psychologists pretty well agree that we can use the construct of *need* in accounting for behavior (some prefer the term "drive" or "motive," but the basic notion is the same). In using the term *need*, we will not go far wrong in conceiving a need to be *a tension a man carries around with him.* It is a tension which will, under the proper circumstances, lead to observable "seeking-behavior." Under the influence of an activated need a man will keep going until the need is satisfied. He may use behavior patterns he has found to be adequate in the past. Or he may simply thrash about at random. Or he may go in for what he would recognize as intelligent, problem-solving behavior. At any rate, he keeps going until he finds something to satisfy the need. When he finds that something, seeking-behavior ceases.

PRIMARY AND DERIVED NEEDS

The classification of needs according to their dependability helps considerably in our attempt to come to grips with the nature of human nature, but it is not the only useful way of viewing them, not the only way of slicing the

cheese. Needs are frequently classed as *primary* or *derived* (secondary).

Primary needs are the needs rooted in physiological necessities and conditions. This category includes all the needs in the "most dependable" class described above, with sex, obviously based on physiology, thrown in. We know more about these needs, in a way, than about the more elaborate needs. We have some information about the physiological mechanisms involved in the arousal and satisfaction of these needs. Because there is something solid for the constructs of hunger, thirst, and sex to rest on, some people are much happier in talking about these needs than about such needs as gregariousness or aggressiveness. They try to explain human behavior in terms of these primary tensions. Most psychologists agree, however, that you can't really do an adequate job of explaining a man's fervent desire to become a big shot by referring directly to his need for food or love. Life is not to be so simply dealt with.

Most of the primary needs can be regarded as *vital* needs—needs that must be satisfied if the organism is to survive. Oxygen, food, water *must* be taken into the body. The organism *must* rest sometime. But it can survive for its allotted years without any sexual satisfaction. The organism will often regard itself as unhappy if there is no sexual activity in its life, and sexual deprivation may result in peculiar maladjustments. But sex isn't necessary—for survival.

DERIVED NEEDS

Most of the tensions people carry around with them are derived. Instead of being internally connected with physiological necessities or preferences, they are social. They are *learned* needs, presumably derived, through elaborate learning processes, from the primary needs. The derived needs, as we have seen, may be relatively dependable. Gregariousness, for example, is a need found in almost all people. Most people like to be with people and are vastly unhappy when isolated from people. But while the majority is learning to like being with people, a minority is learning to *dislike* being with people. Like hermits.

The needs that account for the human behavior around us are mostly derived needs. The same derived need may be found in a vast majority of human beings. But that does not mean the need is a necessary part of man's nature. It means instead that many men have gone through similar learning processes and have learned to need the same things.

CULTURE AND NEEDS

Man comes equipped with very few needs. But by the time he has lived a dozen or so years his needs appear so numerous and varied that we have a hard time even classifying them. The instinct psychologists used to maintain that man's needs became more numerous and varied as he grew up because many of his native propensities unfolded or matured only as the organism developed. A more sensible explanation, and one that fits the facts more closely, is that man *learns* his needs. Living in a certain school environment, he becomes needy in the ways his environment dictates. If this is true, his needs will vary from one social environment to another. Such, indeed, is the case.

Each individual is born into a culture. People around him have certain established ways of going about life. They know what is good, what is bad, what is success and failure. They have definite notions about morality. They possess established habits of work, play, cleanliness, lovemaking and eating. They revere certain institutions which they have created to meet common problems and common needs. These habits, values, assumptions, morals, customs, and institutions vary tremendously from one culture to another. The social climate in New Guinea is not the same as that in Tokyo, Kalamazoo or Delhi. The individual must make peace with the culture into which he happens to be born. The process of making this peace is largely a process of learning the culturally endorsed needs.

With respect to *primary* needs, the cultural pattern into which a person is born has a tremendous influence. Take hunger again. We can depend on it that a man will eat. But when, how often, and what he will eat we never can tell until we know how the man's digestive

processes have been trained. In some cultures man experiences hunger three times a day. In others, people's stomachs contract only twice a day. The American Indian warrior, as is well known, sometimes did not eat for many days. (We do not know whether he was really hungry during the time, of course.) When we come to *what* people eat—what they want to eat— the variation from group to group is tremendous. The Algonquin Indians consider skunk a delicacy. The English like sole and flounder. In Newfoundland sole and flounder are regarded as fit only for fertilizer. In England clams are thrown away or used for bait and mussels are saved for the table. In America clams are eaten and mussels spurned. Horse meat in most of Europe is standard table fare. In America the suggestion of eating horse causes some people to gag.

In the case of sexual desire, the same sort of thing obtains. You can generally count on people to be interested in sex. But the questions of what sort, when, under what circumstances, and with whom can only be answered if we know something about the culturally determined prohibitions and preferences the individual has learned. The individual's physiological needs are timed and trained by the daily routine of his tribe, his class, his nation, his culture.

Little of the behavior stemming from primary needs is free of drastic cultural influence. In the case of *derived needs*—social needs—the role of culture is even more complete. Culture determines the needs themselves and also has a determining influence on the where's, when's, and how's of the behavioral results of the needs.

THE NEEDS OF THE INDIVIDUAL

Individuals in the same culture, even in the same family, differ enormously in the strength and variety of their needs. One man has a constant, burning desire to increase his professional or military status. The need to get ahead is his paramount need, flavoring all his activities, helping determine who his friends will be, whom he will marry, how much he will work, his relations with his superiors and his inferiors. Another man may have such a strong need for sociability that he chooses friends instead of success, that getting ahead is relatively unimportant. One man needs food or sex much more often and in greater quantities than does another. One man spends a life seeking economic security while another hunts for adventure and variety.

A knowledge of human needs in general will help somewhat in understanding the single individual. But to make real predictions about an individual we must find out what needs will account for *his* behavior. The process of establishing needs for the individual is the same as the process employed in settling on the needs of mankind in general. We observe the man's behavior and create in our own minds a construct that will account for his behavior. If the observation is good and the construct is clear-headed, we can predict what he will do in a future situation. Take this example: if, on the basis of careful study, we conclude that a particular CPO has a strong need to dominate, we will not, if we can avoid it, put him immediately in charge of a first class petty officer who violently hates to be dominated. We can predict certain unfortunate behaviors in such a situation.

THE WORKING OF NEEDS

Later we will consider what happens when needs are blocked or when they conflict with one another. At the moment, however, our thinking about needs will probably be clarified if we get a picture of multiple interesting needs operating to produce behavior. Very infrequently, if ever, can we account for a person's behavior by naming a single need—even if we have been forced by observation to create that need. Needs interact. Several needs may be operating at the same time. The man who is hungry, sexy, status-seeking, and gregarious at the same time will behave, if he can (which is rare) in such a way as to satisfy with one adjustment all his tensions. If these needs are all strong and persistent, his general way of life will tend to be a *resultant* of these needs—an elaborate course of action growing out of the many interacting tensions. The point to remember here is that human behavior occurs in something analogous to a *field of forces*. A *pattern* of tensions leads to *resultant* behavior.

To understand and predict human behavior we must contend with something more than single needs and simple cause-and-effect relations.

CONFLICT

In some situations the satisfying of a need is a simple process. A man with a strong need for food or rest may almost automatically perform those acts found in the past to be useful in satisfying his needs. In a very simple way the need leads to familiar patterns of behavior which very simply lead to satisfaction. Everything is fine—until the need becomes strong again. Then the same habitual sequence transpires again, sometimes almost identically, sometimes with negligible variations to take into account minor changes in the environment. When the individual can turn on adequate responses, when the need-satisfying behavior is all ready to go when the need-signal is given, life is simple.

Very rarely does human behavior happen in such a simple way. We have seen that at any one time the individual is moved, not by a single need but by plural needs—maybe a few, maybe many. In such a case his behavior will be a resultant of his interacting needs. The behavior that grows out of an interacting pattern of needs is sort of a compromise. No single need can have its way entirely. It must give in at least a little to the demands of its fellow needs. This sort of process makes the satisfaction of needs an intricate affair. It also makes it next to impossible, in any realistic life situation, to satisfy *all* needs. Sometimes a man may adopt a course of action that will *partially* satisfy all of his needs. Sometimes he behaves so as to satisfy his needs *one at a time*, holding some in check while others are being gratified. Sometimes he may deny one need in order to satisfy a number of others. Sometimes his needs are diametrically opposed, and the satisfaction of one means that the other will be permanently ungratified.

When a man is caught in a situation where his needs push him in opposite directions, where he wants to eat his cake and have it too, he is in *conflict*. In such a situation he will do things that may be judged as peculiar but which are very human.

THE NATURE OF CONFLICT

The individual is almost continually getting himself into situations where he must choose between eating his cake and having it too. The conflicts vary from highly charged ones, where strong needs are involved, to mild little conflicts where an easy choice comes immediately. Our pattern of needs is so complicated that only rarely can we react wholeheartedly to one of life's situations. Almost anything we do or seek has its advantages and disadvantages. "I'd like that . . . but . . ." is the characteristic feeling about a majority of the things we seek or think about seeking. That "but" is an introduction to the disadvantages.

TYPES OF CONFLICT

We can roughly classify conflict into several types. The first type is exemplified by the sex dilemma of the individual whose thoughts make the brothel *attractive and repulsive at the same time.* In our daily lives this sort of conflict is very frequently encountered. We want to succeed in our chosen career but succeeding in that career means hard and often disagreeable work. We want to marry but wives mean responsibilities. We want sea duty but sea duty may mean long absence from many friends. We like to drink but drinking means hangovers. In many—maybe most—life situations we have to take the bad along with the good. Such conflicts become serious, leading to real indecision, only when the goods and bads are strong—and approximately equally strong.

A second type of conflict occurs when we have to choose between *two equally attractive courses of action.* Shall we go to the dance or go to the movies? Shall we marry Mary or Marie, both of whom are ready, willing, and attractive? Shall I spend my extra money on a Cadillac or a yacht (or on a coke or a root beer)? Having to choose between two equally pleasant courses of action is the most desirable sort of conflict to get into, of course, but it still can interfere, at least momentarily, with the smooth and effective flow of behavior.

Then there is the less agreeable sort of situation where we must choose between *two unattractive courses of behavior*. Since my uniform hasn't come from the cleaners, shall I get it

and report to duty late but pressed, or shall I report on time and unpressed?

REACTIONS TO CONFLICT

When an individual is caught in a conflict situation the smooth and adaptive flow of behavior is interrupted. Various sorts of things happen.

Paralysis.—If the conflict is severe, the individual may simply "freeze." He is unable to do anything. The story is told about the jackass who found himself exactly half way between two piles of hay. Unable to decide which to eat, he starved to death. This sort of paralysis does happen in everyday life—though rarely is it connected with the choice between two equally attractive courses of action. It is likely to occur when there is *ambivalence*—where something is attractive and repulsive at the same time.

Many cases of so-called laziness are probably explainable as paralytic reactions to conflict. The lazy man, if he is studied carefully, often turns out to be the man who is in conflict. He wants to achieve, but the road to achievement looks very tough and thorny. Or he may fervently desire success but at the same time feel that his chances of failure are so great that he is afraid to try. Hard work is good in that it may lead to success. But it is bad in that it will probably lead to failure. In such a conflict a man is likely to just sit, being miserably unhappy and, to the common-sense observer, lazy.

This sort of conflict often has a lot to do with personal efficiency. Most men will work as long as work promises to get them somewhere. They will not work when work promises to bring failure, or only small rewards, or downright punishment.

During the war a group of officers became interested in morale among naval aviation cadets in intermediate training. In anonymous interviews the cadets were asked this question: "At one time or another in your life you have probably had a job at which you worked with great enthusiasm and efficiency, where you felt you were working at your best. If you rate your best work efficiency at 100 percent, what would you say your present work efficiency is?" The cadets appeared to have no difficulty in understanding the question and the interview situation was staged so that honest answers were likely. They put their present efficiency anywhere from 40 to 100 percent with the average around 65 percent. This means that the average cadet was performing at what he judged to be 35 percent below his peak.

There was no doubt that these cadets were anxious to get their wings, and most of them appeared genuinely to want combat duty—to "get out where men are men." Why, then, were they not working with peak efficiency toward their goals? There were probably several factors. But in accounting for personal inefficiency in seeking a highly desired goal, a likely place to look for reasons is in the promises held out by hard work. Does it promise success and rewards? Or does it promise failure and punishment? In this case, what factors are there driving the cadet away from hard work? Intensive interviewing suggested two related negative factors: (1) the pervasive fear of failure, and (2) a fear of unfair evaluation of work.

Failure in flight training was a traumatic thing to the average cadet. Many flight-failures were practically ready for suicide. And the possibility of failure was kept continually uppermost in the minds of cadets. Instead of being a chance to learn, to demonstrate skill, to get on toward the goal, every flight, every hour of ground school, became a fearsome chance to flop, to fail, to get a down. This pervasive fear of failure was enhanced by the cadet's feeling that success or failure was often an accidental matter.

In such a situation, real efficiency is highly unlikely. Every hour of work involves high-level conflict. The cadet desperately wants to succeed. He desperately fears failure. If at any moment, the possibility of failure seems equal to or greater than the possibility of success, a man just cannot get wholeheartedly involved in work. Of course, any time he tries to succeed at something he must take the bad with the good, he must suffer some, he must run some risk of failure. If the suffering and risk seem greater than the rewards of success, however, no effort will happen. If the disagreeable aspects of work are too strong, if it looks to him as if the reward, instead of fitting the effort

and the performance, is a matter of luck, his behavior will be continually jittery, inefficient, conflictful. If the chances of success are reasonably good, if it appears that success is not accidental but fairly and inevitably dependent on high effort and good performance, personal morale will be high and work will be efficient. The hardships of work will be taken in stride.

In less involved situations, where individuals are caught in a paralytic conflict, the flow of behavior may be only momentarily interrupted. We have all had fleeting moments of indecision arising out of small conflicts. We generally have little trouble in reaching a decision. What happens is that one need becomes stronger than the other and behavior—as always—follows the strongest need.

There are those of course who will continue to say that the conflict-bound individual is just lazy. And they say that so-and-so, being lazy, needs nothing so much as a good swift kick in the bosom of his britches. Such a diagnosis is never adequate and such a treatment, while it may produce activity of some sort, will hardly result in enthusiastic work. Work happens when work promises rewards to the many needs of the worker. Work will not happen if it promises frustration and unpleasantness. Generally speaking, the more reward-promising the work, the more enthusiastic the worker. If the rewards outweigh the handicaps, the handicaps will be taken in stride.

Alternation.—A second reaction to conflict is alternation. The person in conflict may try one course of action a while, then turn to the other. The hungry rat who can only get food by crossing an electric grill that shocks him pretty viciously will often go toward the food 'til he gets close to the grill. Then he retreats from the grill. This alternate approaching and retreating may go on until hunger gets strong enough to make the shock a thing to be taken in stride. At a considerably more complex level there is the example of the man in serious conflict about morals and religion. One week he was strictly a churchman, strictly a moralist. The next week he would become a confirmed rounder.

In everyday situations we encounter less dramatic instances of alternation. With respect to the sort of work-conflict we have been talking about, for example, the person may alternately work with great zest and loaf with complete flaccidity.

Escape.—The person in conflict frequently behaves in such a way as to avoid having to make a choice. If I stay in this billet I am likely either: (a) to get in trouble with my men, or (b) to have to be relentlessly hard-boiled with them. Both courses of events are distasteful to me. I will request a change of duty. This is an easy escape from conflict.

Sometimes this sort of escape from the arena of conflict is very wise. Doctors who recommend a change of scene, such as a summer in the mountains or a trip to Europe or a winter in Florida, are often simply arranging for the patient to escape temporarily from a situation that throws him into a tense and debilitating conflict.

Physical escape from the conflict situation is frequent and often adaptive. There are psychological escapes, too, and these may not be so conducive to the maintenance of mental health. The individual may dream up for himself a fantasy existence wherein the harsh realities of a conflictful world fade away. This and other sorts of escape reactions will be treated in more detail later.

Problem Solving.—Instead of coming down with paralytic inactivity, instead of alternating between one response and another, instead of physically or mentally escaping the conflict, the individual may find a way to resolve the conflict so he can, in effect, have his cake and eat it too. This, of course, is the smart way out of a conflict.

Actually a physical escape from the conflict situation is a solution—of a sort. The only trouble with it is that it is likely to be temporary. The emotionally upset individual who requests sea duty to escape a conflictful home situation may be playing ostrich. He sticks his head in the sand and his conflict ceases. But he has to come up for air sometimes. When and if he does, there is the conflict again. He hasn't solved his problem. He has only ignored it a while. Perhaps, by virtue of some rest and change of scene, he will return to it with greater ability to wrestle intelligently with it, but the problem is still there.

A lot of conflicts, once a choice is made, tend to solve themselves. Perhaps, while young and inexperienced, a young man is equally attracted to West Point and to Annapolis. Suppose he is fortunate enough to be able to choose which he will attend. He finds decision impossible. He flips a coin. It sends him to Annapolis. Once he takes steps toward Annapolis, West Point probably loses its attraction for him. Once he makes a decision and begins to act on it, the opposing interest falls into the background. He identifies with Annapolis and rarely will he have regrets involving a comparison of the Severn and the Hudson. (P.S. If the coin had fallen the other way, he would have been ultimately just as happy. Either course of action satisfies the basic needs involved. Such a conflict is a conflict of means, not of ends.)

In many conflicts, particularly those involving choice between two good things, any choice is a good solution. In other conflicts, however, no choice is really a good choice. Compromise is a necessary and unsatisfactory course of action. The man who wants sea duty but violently fears seasickness, applies for duty involving only inshore patrol. The man who is fascinated by airplanes but fears to fly seeks a position as ground-school instructor or aviation mechanic.

Much of our lives we live by compromise. We cannot have our cake and eat it too, so we figure out clever ways to have some and eat some. If we can't eat our cake, we find something else almost as good to substitute for it. We cannot expect to avoid conflicts. Life is full of them. We can hope to (a) diagnose our conflicts properly, and (b) go intelligently about the business of finding the best possible solutions for them.

Where do conflicts come from? The more important conflicts result from our acquiring incompatible needs or incompatible behavior mechanisms. Some conflicts, however, arise out of the way the human organism is equipped at birth. It is impossible, for example, to flex and extend a limb at the same time. It is very difficult to rub your stomach with one hand while patting your head with the other. Exerting maximum grip with the right hand seems to prevent maximum grip with the left, and you cannot, of course, look to the right and to the left at the same time. The structure and functioning of the body and nervous system make certain small-time behavioral conflicts inevitable. But the conflicts that tie us in emotional knots are the ones growing out of our derived needs.

It has been observed that our modern culture is particularly likely to breed conflicts in individuals.

Conscience vs. Old Adam.—The sort of conflict that the psychiatrists and psychoanalysts make much of is the battle between our primitive desires and our consciences. We are born with needs for food, sex, etc. Through learning, we develop a conscience whose function is to guide us into socially acceptable ways and means of gratifying our basic needs. In many of life's day-by-day situations, the learned prohibitions and restrictions of conscience do battle with the primitive unlearned animal needs. Conscience, in most of us, wins fairly consistently. When conscience is very strong, conflict, at least at the conscious level of temptation, rarely happens. If conscience is very weak or non-existent, the Old Adam is pretty free to express himself, and there is not much conflict in such a situation either. But when our needs are just about as strong as conscience, conflict can be severe.

In our particular culture such conflicts between needs and conscience are very often centered around sex. In most men sex is a strong need. It is probably made stronger and more important by the standard attitudes toward it. The parents who deliberately or otherwise teach their children that sex is a nasty, hush-hush affair are incidentally teaching their children that it is a fascinating business. The devices intended to control sexual behavior often work to make sex harder to control. But, however strong our sexual needs, our culturally engendered conscience is usually able to exercise control. When the control weakens, however, highly charged conflict results. Out of these conflicts grow such things as impotence or frigidity, guilt feelings, anxieties, and compromise perversions.

Our culture sets the stage for sexual conflicts by teaching a set of prohibitory rules designed to control primitive needs. It also tends to teach us *goods* that are sometimes mutually exclusive. "A wife and a family are

fine things," says the culture, "*but* don't get married until you can afford it and be careful that your family doesn't take up time you ought to be spending at your proper business of getting ahead." The individual who has learned to need a family and learned to need success has something of a conflict on his hands. He must wait, compromise, and often suffer in order to meet these two needs. If he goes wholeheartedly after establishing a family, he will not have time to compete successfully with his fellow succeeders. If he is wholehearted in plying a profession, he will neglect his family. He must evolve for himself some halfway pattern of life that enables him to have some cake and to eat some.

The culture teaches us many of these "but" propositions, each containing a built-in conflict, each demanding some complex problem-solving adjustment if we are to avoid extreme emotional difficulty.

FRUSTRATION

The environment we live in is by no means tailored to the needs of any one person. When a complex individual wrestles with a complex life, it is inevitable that he will be thrown into conflicts. It is also quite certain that many of his needs will be thwarted. He will want things that he cannot, for one reason or another, have. Frustration, in modern life, is frequent and unavoidable.

Frustration occurs when need-directed behavior is blocked. In the simplest case of human behavior we have seen how a need arises, adaptive behavior patterns are turned on, satisfaction is achieved, and the need-tension disappears. But we have seen, too, that only rarely is life so simple. Conflicts interfere with the basic natural process. More cluttering is introduced if some barrier arises to keep the organism from going where it wants to go and doing what it wants to do.

When a man wants something he can't get, whether that something is as trivial as a lost pencil or as all-important as pre-eminence in his profession, he is frustrated. And when he is frustrated, the simple directness of his behavior disappears. He characteristically becomes quite emotional. And his reactions, though they serve a psychological function, may get him nowhere at all. To the casual outside observer, the behavior of a frustrated man may make no sense whatsoever. But frustrated behavior is very human behavior and the man who is going to predict and control human beings will do well to understand something about it.

THE BARRIERS WE MEET

The people, objects, and situations that get in our way as we struggle to satisfy our needs are almost infinite in number and variety. But we can talk about them in terms of six general types:

Strictly impersonal barriers.—The man who is in a hurry to go out but is unable to get his apartment door unlocked presents a good picture of frustration. He may try various alternate ways of getting out and if none of them work, he can be counted on to become agitated and angry. The cancellation of a scheduled airline flight, the reddening of a traffic light, physical distance, fences, walls, busy telephones, malfunctioning engines, low tides and thousands of other impersonal objects can be counted on to interfere with the day-to-day attainment of our goals.

People as people, frustrate us.—People, probably more often and more disturbingly than inanimate objects, hem us in and obstruct the attainment of our goals. People, of course, *facilitate* our goal-seeking behavior too, but when each person has his own needs to worry about, it is inevitable that people are going to get in one another's hair. We can expect almost any human association—even friendship or marriage—to be frustrating at least some of the time. Friends and wives are quite often good things to have around. They satisfy many needs. But friends and wives are people. They have their own needs. And when a friend's needs or a wife's needs run counter to our own, *somebody* is going to be frustrated. And since marriage and friendship are fifty-fifty affairs, the friend or the wife can't be expected to bear more than half the load of frustration.

People, as enforcers of rules, frustrate us.—When any group of people live together—whether as a culture, a nation, a Navy, or a

crew—there have to be certain rules about who shall do what when. These rules are expressed as morals, taboos, laws, and regulations. The completely civilized man *wants* to live in the way the many rules and regulations suggest. But few, if any, of us are so completely civilized that the rules, laid down for the long-term welfare of the many, do not seriously interfere with what we, as individuals, want. These rules are enforced by people. There are policemen, upholders of morality, standers - for - the - right, commanding officers. These people deliberately or unintentionally enforcing the rules the group lives by, sometimes block the personal inclinations of the individual member of the group.

Being frustrated by a person, whether that person is merely an individual trying to get along or a symbol of law, order, and propriety, is generally more disturbing than being blocked by an inanimate object. In the first place, people are harder to figure out than a door that won't open. In the second place, they are supposed to be more sympathetic and understanding than inanimate objects. We expect them to be reasonable and kind; when they aren't, our frustration may be increased. In the third place, if we do what comes naturally under frustrating circumstances and attack the barrier, the human barrier can fight back. It can hurt us physically or professionally, make us feel guilty, make us ashamed of ourselves. We can kick a door in the shins without any serious psychological hangover, but any venting of anger on a human being is likely to produce a very complicated aftermath.

Our inabilities frustrate us.—Sometimes we seem to be our own worst enemies, for our desires are now and again blocked by factors we carry around with us. One built-in frustrating factor is plain inability—plain lack of physical or mental capacity to do what we want to do. Think of the healthy man who loses an arm or a leg or some other frequently employed anatomical appendage. He is bound to experience frustration. The boy who wants to be a college athlete but under no circumstances can get his scales to read more than 125 pounds is very likely to suffer almost excruciating frustration and defeat. Mental incapacity also produces frustration. Every year thousands of young men enter American universities, optimistically heading for law or medicine or engineering, but discovering sadly, after a few months of realistic exposure to life and higher education, that they just do not have the necessary ability to reach their professional goals.

In many situations the individual's plans and expectations overreach his abilities. Through the influence of doting parents, or through an unrealistic self-appraisal, he hitches his wagon to a star. When his wagon turns out to be too rickety for the journey, defeat, bitter and disturbing, is upon him. When an individual's *level of aspiration* is too far above his level of achievement or his level of abilities, frustration is the result.

Conflicting positive motives lead to frustration.—We have seen that in situations involving conflict the individual must often choose one course of action and deny another. Or he must achieve a compromise which partially denies both of his conflicting needs while partially gratifying each. The partially or wholly denied need cannot be counted on to disappear. It stays around, sometimes with great insistence. If a course of action gratifying the first need makes gratification of the second impossible, the second need is frustrated and influences the organism's behavior accordingly.

We have seen that often when a man makes a choice between two attractive things, the denied attraction loses potency the farther he gets away from it. The man who decides to go to Annapolis instead of West Point is not often frustrated by not being at West Point once he is involved in life at Annapolis. But this really is a fairly superficial conflict. The basic needs involved (status, perhaps) can possibly be satisfied equally well be either of the two courses of action. But when we put a man in a situation where strong basic needs are in diametric conflict, one need will be frustrated. The man who finds that he can bring about the sort of status he needs only by achieving priesthood, but who, on the other hand, has strong primary needs for worldly things, is in highly charged conflict. If he dons the cloth, his red-blooded needs are going to be frustrated. If he adopts a way of life wherein red-bloodedness is more possible, his needs for a high religious status will be forever blocked.

He's in for a tough and troublesome life whatever he does.

A positive need vs. a negative one produces frustration.—Here again, conflict leads to frustration. The case of laziness comes again. The man who wants to lick the world, but is locked in inactivity because of fear of failure or fear of unfairness of competition or fear of his own inabilities is a frustrated man. His behavior, what there is of it, will more than likely be characterized by a tense, dissatisfied grumpiness.

Often the negative needs in positive-negative conflicts are needs flavored with fear. The fear of what people will say, the fear of being caught and punished, the fear of making a fool of oneself. These blocks can frustrate positive needs, often more effectively and more disturbingly than any impersonal or external barriers yet invented.

Closely related to the barriers of external social pressure are the conscience-barriers that the average man possesses. When any highly desired course of action conflicts with a man's code or conscience, or with the role he pictures for himself, frustration is likely. If, in time of temptation, the person's conscience is stronger than the conscienceless need, there will be no real conflict and no severe frustration. Or, if conscience is very weak, a man may steal, cheat, or rape with equanimity. But when conscience and need are both strong, something is going to be frustrated. If the man steals, he has the money, but he has a guilty conscience, feelings of shame, and remorse. If he follows his code, he hasn't the material rewards of sinning. The man who gets to be a success by ruthless competition may have a large income, but at the same time he feels the sort of uneasy guilt that makes him into a showy philanthropist. The man who refuses to play according to ruthless rules may have a clear conscience and a frustratingly small bank balance.

In our society—in any society—the rules, regulations, disciplines, and institutions established to make it possible for people to live together without too much friction will often block the private needs of the single individual. When the rules, regulations, standards, and values of a society become a part of the individual's conscience, the blocking of needs still happens. If the individual's conscience and code become very strong, he may experience no *conscious* conflict with his baser motives. But there is some reason to believe that in many cases the individual with the most ironclad conscience still is influenced by his frustrated primary needs. This is a point we will need to consider again later.

REACTIONS TO FRUSTRATIONS

When an individual on his way to a goal confronts a barrier—whether it be of an impersonal or of a built-in, personal nature—his first behavior will generally be of a problem-solving variety. He will scratch around to find some way to circumvent the obstruction. If his attempts to be smart about his problem all lead to failure, behavior soon moves out of the intelligent, problem-solving category and becomes emotional. The child who is placed in a room where he can see a bunch of fascinating new toys but is kept from them by a fence, will first seek a way around or over the fence. When he fails at this, frustration continues and the behavior that ensues becomes emotional and, to an outside observer, strictly strange. There are a variety of reactions to frustrating situations:

Aggression.—Probably the most frequent response to frustration is one of anger and attack. The child, in the situation above, may charge angrily into the fence. Or his aggression may be of the nondirected type you can often see in children's (and sometimes in adults') temper tantrums—a wild and angry and ineffective slashing away at any object within reach. If the frustration is produced by a person, the attack may be directed at that person. If the frustration is due to the individual's own incapacity, the aggression is turned inward—the person will think and say derogatory things about himself and may devise ways to make himself suffer for his shortcomings.

Aggression may take several forms. In children, the direct frontal attack involving physical blows at the object or person, is fairly frequent. In adults, such crude aggressions are often refined into verbal substitutes. The adult will sometimes kick a bothersome chair in its shins or pommel a person who gets in his way. Fist fights, wife-beating and such physical ag-

gressions do happen in adult society, but most often we aggress—particularly against people —by more intellectual devices. We call names, or we ruin character, or we spread scuttlebutt, or we withhold approval, or we play practical jokes, or we haze. Man has a pretty complete collection of subtle devices for making his fellow man suffer—when his fellow man frustrates him.

Aggression may not always be a direct attack on the object or person that is doing the frustrating. There is such a thing as *misplaced aggression.* The man who comes home after a day during which his CO has strongly disapproved of his work, his fellows have demonstrated a definite coolness to him, and his every attempt to achieve belongingness and effectiveness at his job has met with failure, can be counted on to go in for fairly bearish behavior. He may walk in the house, kick the cat, darn the dog, slam his coat on the floor and belittle his wife's ability as a cook. The pent-up steam of aggression is vented upon things and people who had nothing to do with the frustration that produced the aggressive tendencies.

This sort of misplaced aggression is frequent. It often has serious consequences. The aggression may be misdirected because of two reasons: (1) the individual may not be able to diagnose and understand what is frustrating him; and (2) the individual may know what is frustrating him, but also knows that it is very unwise to attack the frustrating object or person.

There are many frustrating situations in which he cannot understand what it is that's causing our trouble. In time of depression, for example, though frustration is widespread, we are unable really to appreciate the complicated and interlocking economic factors that cause the distress. And even if we did understand, there would be no way of attacking an economic cycle or overexpansion or excessive inventories. The frustration is concrete, nevertheless, and our tendency to aggression is present and strong. So we very often find something or someone to blame. The President is a handy person to blame; Congress, too. And in hard times the President and Congress, who probably have only a negligible part, if any, in causing our troubles, are viciously berated in the press, in drawing rooms and in pool halls, and very often they are turned out of office. During war, when frustrations are plentiful and hard to diagnose, the aggressions of the people are turned on all sorts of concrete get-at-able and relatively blameless stimuli. The President and Congress are always there as lightning rods to catch our aggressions, and there's the Navy, the Army, the Jews, the munition makers, the Negroes. All these, in time of national duress and frustration, catch more hell than they deserve. Aggression will out. If we can't put our finger on the causes of our troubles, we'll pick on something or somebody else.

The well-known phenomenon of *scapegoating* is accounted for in terms of misplaced aggressions. When frustration is extreme and the source of frustration is either unknown, unavailable, or unsafe to attack, there is a tendency to pick a "goat" to visit our aggression upon. In any group, the scapegoat phenomenon can be expected to occur if the situation is right. If the members of a crew are frustrated, they may pick a certain member of the crew or occasionally a junior officer to focus their aggression upon. The officer or man who becomes scapegoat will usually be one who (1) is get-at-able, (2) cannot fight back successfully, (3) is "different" from his fellows, and (4) appears, at least superficially, to deserve ill-treatment.

Any crew in the Navy is trained to bear up under certain necessary frustrations. But in any circumstance where the crew is denied too many satisfactions—if liberty is too long restricted, if pride in the unit is impossible, if conditions of work lead to uncertainty, insecurity, and a feeling that rewards and punishments do not make equitable sense—aggressive attitudes can be expected. And, conversely, when the crew or any of its members becomes embroiled in group or private aggression, you can profitably start an immediate search for frustration. The aggressions of a frustrated crew may take the form of recalcitrance in the presence of officers, the choosing of a scapegoat, outbursts of fighting on board or ashore, general surliness, and refusal to work.

We have seen that aggressiveness is a widespread form of human behavior. We have also seen that it is not a universal form of human

behavior. Evidence indicates pretty clearly that aggressive behavior happens only as a result of *frustration.* While frustration may produce other than aggressive behaviors, aggressive behavior—whether in the group or in the individual—can always be traced back to frustration. This generalization is one of the most helpful the leader can learn. It will guide him on numerous occasions in the diagnosis and control of human behavior—his own included.

Regression.—The child who sees lovely and unobtainable toys on the other side of an impassable barrier may first attack the barrier. Then, experimental observations have shown, he is very likely to go in for play activities that characterize a much younger child. He *regresses.* In the face of frustration he adopts patterns of behavior that he used years ago.

Children, of course, are not the only people who regress. Some shell-shock patients regress to infancy and must have their diapers changed and their bottles equipped with nipples. More normal instances of this sort of behavior occur every day. Often in tough and frustrating situations, adults will behave childishly. The temper tantrums in adults may be regarded as an attempt to use a procedure once adaptive in handling troublesome parents.

Adults, when confronted with frustrations, also go in for other childish symptoms. They sometimes pout. They sometimes cease thinking and go in for broad, emotional, childish generalization. They feel and articulate a desire to return to the "good old days." When any adult starts wishing for the bygone days, the days when life was simple, you can generally bet he is finding his present problems a little beyond his ability to solve.

Apathy.—The frustrated individual, hemmed in by barriers and confronted with continual failure may sink into a state of hopelessness and apathy. He gives in, quits trying, convinces himself he doesn't care. This sort of apathetic resignation has been observed in such people as prisoners of war, Europe's displaced population, the chronically unemployed, the hopelessly crippled. It is an attitude of complete surrender. The individual, unable to work out any sort of adjustment to a bitter and hostile environment draws into himself, quits trying, becomes passive, gives up. The mental patients classified as *involutional melancholias* have reached an extreme stage of apathy and depression. In normal cases, we encounter a sour and pessimistic view of life, a depressed expectation of nothing good.

Fixation.—Sometimes the individual reacts to frustration by falling into repetitive, stereotyped patterns of behavior. This sort of reaction is known as fixation—a compulsive continuation of behavior that apparently doesn't get the organism anywhere. A rat, if put into a problem situation where no answer is possible, but where some sort of answer is strongly needed, may resort to such maladaptive fixations as bumping his head repeatedly against a cage door without even trying the next door, one that would let out his dilemma. Human beings do the same sort of thing.

Probably the most interesting sort of human fixations occur on the intellectual level—in the thinking of people. The man who fixates in such a fashion is not the man who meets new problems with an open mind and a vigorous optimism. He resists new problems. He will not even listen to new solutions to old problems, for objective listening would demand objective evaluation, a process he finds psychologically painful. He already *knows.* He accepts new information only when it agrees with what he knows. He has what Wendell Johnson has called the "Maginot Line Mentality."

Repression.—When conscience does battle with conscienceless needs, the resulting emotional stew is highly flavored with guilt and shame. If conscience is strong, the need, of course, is frustrated. But because the individual is ashamed to admit that he could have such a need, the frustration is different from other sorts of frustration. The man who esteems himself as highly honorable and respectable is seriously disturbed if he realized he is strongly tempted to steal, to rape, or to commit some act equally foreign to the complimentary picture he has painted of himself. In such cases he can restore his self-esteem only if he can forget the temptation, pretend it never happened. Very often in such cases of conflict between the Old Adam on one hand and self-esteem on the other, the basic need is not only frustrated, but is also *repressed,* is shoved out of conscious memory.

This notion of repression is strange to most people, but to give it credibility, all we have to do is to observe the convenient way our memories work. How much more often do we remember incidents of which we are proud then we do incidents of which we are ashamed? The former sort of event we keep fresh by telling people about it. The shameful incident we let slide into oblivion by not even telling ourselves about it. Eventually it may be lost entirely to memory. When the shame and guilt are multiplied, the tendency to forget, to repress, is magnified.

The needs thus repressed, though no longer recognized consciously by the individual, do not cease to influence behavior. Needs do not disappear, tensions do not dissipate, simply because we prefer they not exist. According to one theory (the psychoanalytic theory) repressed needs live on in the realm of the unconscious and not only influence later overt behavior, but reveal themselves in fantasy life and in the elaborate symbolism of dreams.

These distasteful needs, the theory goes, are often *projected* into other people. We tend to see in other people those unseen and disagreeable repressed needs we ourselves have. This, in simplest terms, is the old notion that it takes a thief to know a thief. It has often been observed that people who expect the worst of their fellow men, who see sin where other people do not, are people with the most strait-laced consciences. The man who busies himself with other people's morals, who combines suspicion with a puritanical code of behavior, may be the man who has done the most repressing of his own wayward needs. Often, too, the man who crucifies the sinner most unmercifully, usually in the name of religion or ethics, is, by punishing the transgressor, at the same time telling himself that his own repressed needs are horrible things and had better stay repressed. The too obvious, the too blatant, the too intolerant conscience, according to the psychoanalysts, is a good sign of extreme and unhealthy repression of normal tendencies concerning sex, elimination, or aggression.

Substitute goals.—The frustrated individual, denied one goal, may cast about for something almost as good. The man who wants to be a naval aviator but who washes out of flight training may enter aerial navigation and at least partially satisfy his needs. The man who wants to play football may, after a season of sitting on the bench, turn his energy to soccer or lacrosse where his abilities are more adequate. Such adjustments to frustration generally make good sense. Certainly the reflection of energy into constructive and compatible paths is more rational than scatterhead aggression or apathetic resignation.

Where the frustration is due to some physical or mental disability, the original energy sometimes appears greatly increased, and when turned loose on substitute goals leads to great accomplishment. This is called *compensation.* Theodore Roosevelt is one of the best known examples of this reaction to frustration. A puny child, he conditioned himself unmercifully until he became the rough-riding picture of virility. Then there is the homely girl who becomes an excellent conversationalist, or the pimply-faced boy who develops great skill in ballroom dancing. And there's the officer who fails miserably at shore-based administration but who becomes remarkably proficient as a destroyer skipper.

The basic need in most cases, of course, is the need for status and acceptance. When one road to status is blocked, the adaptive thing to do is find another way. When the second way is found, the travelling thereon seems more energetic by virtue of having encountered a few rocks on the first.

Escape.—The individual who meets with failure in his attempts to satisfy his needs may, as in the case of conflict, seek to escape. Escapist activity can be *physical* or it can be *psychological.* The person may physically hie himself away from the frustrating situation or he may psychologically do the same thing by creating for himself an imaginary world where all is serene and he reigns supreme.

Some highly active people, when caught in the throes of frustration, appear prone to get physically away from the predicament. They go to California, or quit their jobs, or catch a plane for Reno, or go home to Mother, or join the Foreign Legion, or sign on as a deckhand on an Oriental freighter, or they go a.w.o.l.

Other individuals appear to prefer psychological escape into realms of rich and satisfying

fantasy. Daydreaming is an almost universal pastime. We all meet frustrations; we all, at least occasionally, dream up wishful fantasies in which we may play the role of the destroyer skipper stuffing mattresses in the shell holes and bringing his battered ship back to port, thereby winning the acclaim of the nation. Such imaginal activity is perfectly normal and some observers even believe it to be helpful occasionally in suggesting solutions to our problems. Fantasy becomes pathological only when the person begins to believe his fantasies and deny the real world. Then, fantasies become delusions. The misunderstood Napoleons in our insane asylums are people who live their lives in their private fantasy worlds.

Commercialized fantasy is an interesting phenomenon in modern civilization. The movies, magazines and books-of-the-month are, for the most part, little more than standardized day dreams. Pay your money at the box office or at the rental library and you are afforded an hour or three of delightful escape from the humdrum realities of a frustrating life.

Emotional exhaustion or neurasthenia.—A protracted emotional battle with frustration sometimes simply exhausts the individual. He develops a chronic fatigue, insomnia, restlessness, irritability, a pervasive lack of enthusiasm. This sort of reaction may, in extreme cases, develop into a complete physical and psychological collapse. It then becomes nervous breakdown. In the services it is one form of combat fatigue.

Hysteroid reactions.—Prolonged emotional stress has definite effects upon the physiological workings of the body. The emotional factor in stomach ulcers is well-recognized. But the severely frustrated or conflictful individual may also develop symptoms that look medical in nature but for which the medical profession is unable to prescribe. These symptoms are called *functional* or *hysterical* symptoms. The aviator with a mortal fear of flying may attempt to solve his problems by coming down with diarrhea or severe stomach upsets while flying. The seaman may escape the fear of fighting by developing a functional paralysis of a leg or a functional anesthesia of an arm or a functional blindness. Shell-shock patients often show such symptoms. To the individual the symptoms are real, but no bodily basis can be found for them.

FRUSTRATION TOLERANCE

In the process of growing up most of us learn that needs cannot all be satisfied immediately. We learn to work before we achieve. We learn to deny ourselves today so we can enjoy ourselves tomorrow and next year. We learn, most of us, to delay gratification of our needs. And, with the inevitability of frustration in our complicated lives, this is a very handy lesson.

Some people, however, never learn to tolerate frustration. The inability to delay gratification may be due to long practice at being a "spoiled brat." Nobody really knows much about the genesis of this aspect of personality, but the theory that frustration tolerance is learned has a certain plausibility. The child who is not frustrated enough, whose every wish is gratified easily by very lenient parents, may go through life expecting the good things to fall into his lap if he is merely cute or pleasant. On the other hand, the child who is frustrated excessively may get more than a healthy amount of practice at adopting maladaptive responses such as fantasy, aggression, repression, or regression. He, too, may be unable to sustain realistic effort in the face of frustration.

Frustration tolerance is a pretty essential attribute for anyone who must absorb extensive training before he can assume the responsibilities and regards of an established position in life. The man who hopes to be an officer in the Navy, for example, who strongly wants the status, responsibility, and income of high rank, must tolerate a salutary frustration for quite a while. Not until long after his formal training is completed will he really begin to gratify his needs. The "spoiled brat" would never be able to take it.

SYMPTOMS AND CAUSES

The doctor who treats the fever and ignores the virus, who cures the cough while the lungs disintegrate, will soon find himself without many patients. The psychiatrist who moralizes over the sins of his patients and clucks at their shortcomings will probably produce more neuroses than he cures. And the ordinary human

being, priding himself on his common sense, who treats the *symptoms* of conflict and frustration while remaining insensitive to the causes, will hardly achieve the utmost as a handler of men. He will punish laziness and expect it to disappear. He will call aggressive behavior "meanness" and deal with it is if the aggressive person deliberately intends to be mean. He will diagnose regression as stupidity, fixation as stubbornness, escape as a "yellow streak." He will attack these symptoms and sometimes he will succeed in making them disappear—temporarily. Sometimes his beating on the symptoms will seriously aggravate the disease behind his symptoms. Common sense diagnosis and common sense treatment of people's behavior is not all it has been cracked up to be.

Behavior is caused. Normal, everyday behavior is caused. To understand normal behavior, to control it, we must get beyond symptoms and deal with the psychological factors producing the symptoms. The present treatment of conflict and frustration has been designed to help the leader see some of the dynamics of behavior so that his understanding of it and his controlling of it will rise a little above the common sense level—the level of laziness, stupidity, mulishness, and meanness.

THE MEDICAL OFFICER'S RELATION TO PSYCHOPATHOLOGY

Most of the reactions to conflict and frustration are strictly normal phenomena. They occur every day and must be dealt with every day. Such reactions as neurasthenia and hysteria are statistically rarer and, though they have normal counterparts, are generally regarded as pathological. Extreme behavior in any of the nine directions we have talked about is classed as neurotic or psychotic.

The medical officer should be able to recognize abnormal behavior when it occurs in his unit. Since the abnormal is almost always merely an extreme form of the normal, the study of everyday behavior should aid in recognizing the serious departures from the everyday.

The medical officer's first job with respect to abnormal behavior is to recognize it and see that it receives treatment.

The medical officer's second job is to maintain an objective attitude toward mental illness. We have seen that behavior is caused. People do what they *must* do in any situation. The man who vomits at the thought of actual contact with the enemy, or the aviator who has dizzy spells during every flight should not be regarded as a weak or cowardly or willful slacker. To regard them in such moralistic terms is to ignore the basic scientific point of view. Men with such symptoms are sick. They behave as they do because they *must* behave as they do. They need treatment if they are to be restored to usefulness. Only rarely, if ever, will accusations of "yellowness" be effective treatment. A vigorous "eating out" may remove a symptom, but will not touch the cause of the symptom. If one symptom is "cured" another can be counted on to show up.

To understand and control human behavior, either normal or abnormal, we need to deal with it on the level of causal dynamics rather than in terms of superficial common sense.

THE READJUSTMENT OF MALADJUSTMENT

Maladjustments come about as a result of conflict and the psychologically inadequate attempt to fulfill one's needs. It should be emphasized that such maladjustment or misadjustment is common in the lives of all of us, and we are often able to correct our mistakes and bring about a satisfactory settlement of the problem that had earlier confused us. However, problems vary in complexity, and humans vary in their skill at solving them. Consequently, physicians in general private practice, naval flight surgeons, psychologists, psychiatrists, ministers, college deans, industrial personnel workers, and many others spend much of their time attempting to help people who are in trouble.

Sometimes the help that is given is primarily environmental in nature. The physician recommends that the harassed business man take a month's trip to Florida. The industrial personnel worker arranges to have the worried worker transferred to another department where the foreman is more congenial. Or the flight surgeon has a talk with the jittery pilot's skipper in an attempt to bring about more un-

derstanding. Such manipulation of the environment may bring about temporary relief from the tensions of the moment and may even make it possible for the person needing help to work out a solution to his deeper problems.

There are many cases, however, where environmental therapy is of little promise, and correction of the maladjusted person's own attitudes seems called for. Such treatment, though known by many other names, is most commonly referred to as psychotherapy or counseling. Since a large part of the flight surgeon's services fall in this category, it seems worthwhile to discuss briefly some of the problems involved.

Because of the wide range of persons who have commonly been called upon for help of this sort, there have been many methods of treatment employed, some probably worse than no treatment at all. Even in the hands of those who would have liked to know better just what to do in each case, psychotherapy was for a long time an art that varied according to the personality of the psychotherapist. To a degree, this is still true. However, there are signs today of a science of psychotherapy arising to replace the art of the past. No longer is it claimed that psychotherapeutics is beyond the reach of investigative techniques. Today, the use of phonographic recordings of interviews, with subsequent analysis of the techniques involved, is a regular part of certain units in clinical research, and follow-up programs help to evaluate the methods used.

It is impossible here to go into detail concerning accepted procedures. However, certain basic notions have evolved that should be mentioned. Perhaps the most important principle that is generally recognized by those trained in this field is that to interfere in anyone's life is a serious proposition, and that the wrong kind of counseling can be worse than none at all. Many old-fashioned approaches toward helping others are in ill favor and on their way out. For example, it is generally felt today that exhortation, sometimes with threats, is ineffective, and that pledges and promises as a result of such exhortation cannot be expected to effect any deep-seated change. The dean of men who reprimanded the delinquent student, assured him that he could do better, threatened him with dismissal if he didn't improve, and finally exacted from the student promises to do better, was probably wasting his time so far as any real help to the maladjusted student was concerned. His threats might conceivably have increased the student's awareness of his own danger, but if the student was already under undue pressure and nervous tension an increase in his fears could hardly be of help.

So it has come about that many ideas of counseling have been laid aside, and even the once widely accepted techniques of reassuring and encouraging are now recognized as often inducing a person to ignore his problems instead of facing them and solving them in wholesome fashion. In fact, the question has now arisen as to when a counselor or psychotherapist should, if ever, attempt to solve a client's problems for him. Even the time-honored phrase "If I were you" has come to be less and less used as the idea has grown up that "I" can never be "you"; neither can "I" ever completely "put myself in your place." When the counselor tries to solve his client's personality problems, we know now that he may be solving only his own. The psychotherapist may tell another person how his life should be lived, but what the client needs is to grow up emotionally to the point where he can live his own life without dependence upon anyone for such advice and guidance. Consequently, the giving of advice or the use of persuasion to induce behavior to the liking of the psychotherapist may succeed in bringing about the alleviation of symptoms, but will probably have no beneficial effect upon the causes of those symptoms.

What is perhaps the opposite extreme in viewpoint has been presented as "nondirective" counseling. It is based on the following ideas expressed by Rogers: "Effective counseling consists of a definitely structured, permissive relationship which allows the client to gain an understanding of himself to a degree which enables him to take positive steps in the light of his new orientation. . . . All techniques used should aim toward developing this free and permissive relationship, this understanding of himself in the counseling and other relationships, and this tendency toward positive, self-initiated action."

Considering the type of problem and the intelligence of the subject that is most likely to be encountered by the flight surgeon, this approach seems to hold great promise. In the majority of cases the flight surgeon is unlikely to have sufficient background and training to be justified in employing such techniques as hypnotherapy, narcosynthesis, psychoanalysis, or definitely directive methods of counseling, but proper use of the nondirective technique would be relatively safe, and might be expected to give definitely beneficial results.

BIBLIOGRAPHY

1. Barker, R. G., Kounin, J. S., and Wright, H. F., editors *Child Behavior and Development.* New York: McGraw-Hill Book Company, 1943. (Chapter 26.)

2. Dollard, John, Doob, Leonard W., Miller, Neal E., Mowrer, O.H. and Sears, Robert R. *Frustration and Aggression.* New Haven: Yale University Press, 1939.

3. Heggen, Thomas, *Mr. Roberts.* Boston: Houghton Mifflin Company, 1946.

4. Horney, Karen., *The Neurotic Personality of Our Time.* New York: W. W. Norton and Company, 1937.

5. Hunt, J. McV. (editor) *Personality and the Behavior Disorders.* New York: The Ronald Press Company, 1944. (Volume I, chapter 14.)

6. Maier, Norman, R. F., *Psychology in Industry.* Boston: Houghton Mifflin Company, 1946.

7. Rogers, Carl R., *Counseling and Psychotherapy.* Boston: Houghton Mifflin Company, 1942.

8. Ruch, Floyd L., *Psychology and Life*, 3rd Edition. New York: Scott, Foresman and Company, 1948. (Chapters 13, 14.)

9. Shaffer, Laurance F., *The Psychology of Adjustment.* Boston: Houghton Mifflin Company, 1936.

10. Snyder, William U., Present Status of Psychotherapeutic Counseling. *Psychological Bulletin*, 1947, 44(4), 297-386.

CHAPTER 9

NEUROPSYCHIATRY IN RELATION TO AVIATION MEDICINE *

The subject of neuropsychiatry is hereby presented in what amounts to a brief outline of the course as given by the Department of Neuropsychiatry in the School of Aviation Medicine, U. S. Naval Air Station, Pensacola, Florida. A basic knowledge of psychiatry is assumed. Certain psychoanalytic concepts and the psychobiological point of view are related as they are applicable in the work of the naval flight surgeon. From the resident course of 40 lectures and 20 seminars, selected subjects are presented here for the information of medical officers who are not themselves engaged in the practice of psychiatry. Resident students at the School of Aviation Medicine, in addition to the didactic work mentioned above, also receive supervised clinical work on the wards of the U. S. Naval Hospital, Pensacola, Florida.

In order to achieve brevity in this presentation, liberal use is made of references, to which it must be assumed the medical officer will have access.

LECTURE NO. 1

Introduction to neuropsychiatry in aviation:

1. Why study psychiatry?
2. What is the psychiatric role of the Flight Surgeon?
3. Relation of psychology and psychiatry.
4. Discussion of the course to be given.
    a. Reference and textbooks.
    b. Collateral reading.
    c. Seminars.
    d. Patients.
    e. Hospital clinics.
    f. Vocabulary.

* Prepared by LCdr Philip B. Phillips, MC, USN.

Since aviation medicine is a specialized form of industrial medicine, wherein personal relationships, attitudes, and the effect of emotions on the individual are of primary importance, it is obviously necessary for the flight surgeon to be conversant with modern psychiatric thought. Personal, social and emotional problems are as great a cause of non-effectiveness in aviation as hernia, ulcer, or fever. Psychiatry is presented as an intelligent approach to our everyday relationships with people, in that we deal with behavior, one's relationship to his environment, and to his fellow man. The neuropsychiatric problem in the Navy is the responsibility of all medical officers; in aviation, it is the responsibility of the flight surgeon.

It is not intended that a flight surgeon should be a qualified neuropsychiatrist nor psychiatrically conscious over all his other duties. Certainly he should not pose as a specialist or attempt to *psych* his shipmates; but he should be psychologically minded and practice modern medicine for the benefit of his men. He should be able to comprehend the dynamic formulation of the doctor-patient relationship, should be familiar with normal personality development, the meaning of psychoneurosis, the common manifestations of psycho-pathology, the effect of emotions in altering physiology, and the more simple methods of treating emotional disorders. Psychology is presented as the working of the normal mind, the inter-relation between organism and environment; whereas psychiatry places emphasis on the mind that has failed to establish harmonious adjustment, or where this adjustment has been disrupted in the inter-relation between organism and environment.

Psychiatry is no longer primarily interested in the end products, but its emphasis has shifted from an interest in *what* to *why*. Emphasis is placed on the concept that the term "normal" includes a wide range of reactions, depending on the individual and environment. Normalcy referring to mental health exists only when the efficiency, the physical and emotional wellbeing, the social behavior, and/or the individual's thinking remain within the socially accepted limits of a specific situation.

Emphasis is placed on the body-mind relationship and the necessity of dealing with mental and emotional problems both from the psychological and the organic viewpoint. The flight surgeon is concerned with two cardinal factors: the personality of the individual and the environment in which that individual finds himself.

*References:**
(E)—pages 53-146.
(P)—pages 9-13.
(S)—chapter I.

LECTURE NO. 2

Development of the mind and personality:

1. Psychosomatic relationships.
    a. The influence of the mind on body functions, and vice versa.
2. The origin of the mind.
    a. The levels of the psyche:
        (1) Tropism.
        (2) Reflex.
        (3) Instinct.
        (4) Intelligence.
3. Influence of environment on personality (body—mind).
4. Requirements for an organism to function at the level of intelligence.
5. Fields of concern regarding relationship to one's environment.
6. A balanced personality.
7. The four-square man.

The constant influence of the psyche on the soma and vice versa is pointed out. In fear, the physical accompaniments of tachycardia, dry mouth, dyspnea, and often nausea and vertigo occur. The reverse is also true, for if one suddenly experiences one of the latter symptoms, apprehension or fear is the result. Thus it is held that the body-mind relationship is a constant and dynamic one.

Apparently the mind has developed in order that the organism may be able to solve the increasingly complex problems faced and survive. The four levels of the psyche are: (a) the level of tropism, where behavior is governed chiefly by physical and chemical laws; (b) the level of reflex, where a constant stimulus gives a constant response, illustrated by the actions of an earthworm touched by an electrode; (c) the level of instinct, which is a series of reflex actions, fixed, stereotyped and inelastic, but which may become complex; and (d) the level of intelligence. Here stimuli are received by the cerebral cortex and selectively distributed, and the response and behavior follows no fixed pattern.

Another dynamic relationship exists between the individual and the environment, and illustrations may be readily brought to mind demonstrating the variation of behavior under varying environmental conditions.

The requirements for an organism to function at the level of intelligence are: (a) the ability to form abstractions logically and correctly; (b) the ability to comprehend what others understand and explain; (c) the ability to combine information logically and correctly; (d) the ability to so act as to obtain the desired goal.

The cardinal fields of concern regarding the relationship to one's environment are: (a) feeling; (b) thinking; (c) acting.

A balanced personality has been compared to a four-legged chair, the legs being *love, work, play,* and *worship*. Any leg out of proportion or missing results in an unbalanced personality. The four-square man is an illustration given by Cleeton and Mason in their book, "Executive Ability", wherein they state that the "area" of a man's success is determined by the square enclosed by the four sides: (a) ability (mental); (r) reliability (spiritual); (e) endurance (physical); and (a) action (integration of all factors).

References:
(D)—pages 17-33.
(J)—pages 11-17.
(K)—pages 3-18.
(S)—pages 6-10.
(T)—pages 1-8.

* All references and seminars referred to by numbers in parentheses will be found on pages 186-188.

LECTURE NO. 3

The structure of the personality:

1. Instincts:
   a. Where they exist (the Id).
   b. The pleasure principle.
   c. Aim and object of the instincts.
2. Need for new personality factor to contact reality and adapt to its demands:
   a. Origin of the ego.
   b. Its function.
   c. The reality principle.
3. Need for permanent retention of certain demands and ideas of reality:
   a. The super ego:
      1. Its origin and role.
      2. Manner of acting.
      3. Ego-ideal.

Instincts are held to exist in the portion of the personality known as the Id. They follow the pleasure-pain principle: that tendency of instincts to seek release of tension and avoid the pain of tension. They have no regard for morals, codes, or persons, and disregard logic, time and comfort of others. Their aim is to dissipate the charge of energy which is producing tension, and their object is some thing or person in the world contact which will fulfill the aim of instincts as an avenue of release for tension. Undisciplined instinct gratification cannot last; the growing child must be made aware that some control of expression of desire must be brought about to adapt to social life. A new factor of the personality develops for the purpose of contacting reality and adapting to its demands.

This ego part of the personality arises from the Id and is developed to act as mediator between two forces, the forces of the instincts and the forces of reality. The reality principle is the capacity of the organism to forego immediate pleasure in order to insure pleasure and avoid pain in the future.

A third portion of the personality, the *super ego,* develops for the permanent retention of certain demands and ideas of reality. Repeated parental prohibition gradually is incorporated into this portion of the personality, the super ego. It affects the ego by making it feel fear, shame, disgust, etc., indicating unacceptable Id desires have been stimulated. Parental limitation and imitation both are included in the super ego, which besides its punitive role also includes the *ego ideal,* so that the super ego embraces both necessary social prohibitions and higher cultural strivings.

Recapitulating, it is held analytically that there are three parts to the personality. The driving forces of the instincts exerting themselves through body and mind, demanding love and comfort, make up the Id. Being dependent upon others for this love and comfort, a part of the psyche differentiates itself, taking cognizance of the environment, and begins to hold the instincts to what the environment will tolerate in the way of satisfying instinct tensions. This is called the ego. To save excessive anxiety with each new danger, a third part of the psyche is differentiated, which automatically makes decisions and controls behavior. This is the super ego.

References:
(A)—pages 21-34.
(D)—pages 29-68.
(H)—pages 80-125; 294-342.
(K)—pages 26-29; 35.

LECTURE NO. 4

The psychosexual development of the child:

1. Environmental adaptation problems:
   a. Genitalization of the libido.
   b. Finding external object.
   c. Redirection of excess energy.
2. Genitalization of the libido:
   a. The physical body and its constituents (psychologically):
      (1) Organs of metabolism.
      (2) Organs of internal integration.
      (3) Organs of external integration.
   b. The intellectual capacity.
   c. Instincts.
   d. Erotogenetic zones.
   e. Pleasure-pain principle.
   f. Repetition compulsion.

Ages in the normal psychosexual development to maturity:

Oral	0 - 1½
Anal	1½- 3
Genital	3 - 6
Latency	6 -12
Pubertal or adolescent	13 -on
1. Homosexual	13 -15
2. Heterosexual	16 -?

DIAGRAM OF DEVELOPMENTAL STAGES

(The Theoretically Normal Development.)

A. Libidinal Localization (erotogentic zones).	B. Aim, or Mode of Pleasure-Finding.	C. Libidinal Object-Finding.		
INFANCY PERIOD				
Pregential Period	Infantile sexuality	Auto-erotism*	Narcism	Allo-erotism
1. Oral stage: a. early oral	Sucking, swallowing (incorporating)**	at first object-less		Oral object-choice
b. late oral	Biting, devouring (destroying, annihilating)		Primary Narcism	Oral-sadistic object-choice
2. Anal stage: a. early anal	Expelling (rejecting) (destroying) Retaining (controlling) (possessing) looking, exhibiting, handling, inflicting pain, submitting to pain			Anal and anal-sadistic object-choice
Early genital period: (phallic stage)	Touching, rubbing, exhibiting and looking at genitalia investigating, comparing, questioning, phantasying (tender affection)			Parent object-choice Oedipus-phantasies
LATENCY PERIOD				
No new zone	Repression Reaction-formation Sublimation Affectional trends	Further decline of auto-erotism	Diminished Narcism	Development of social feelings
ADOLESCENT OR PUBERTAL PERIOD				
Late Genital Period Revival of zone sensitivity of infancy period	Reactivation of modes or aims of infancy period	Revival of auto-erotism	Fresh wave of Narcism	Revival of Oedipus object choice
Later, functioning of vaginal zone	Emergence of adult mode of pleasure-finding			Homosexual object-choice Heterosexual object-choice

* Not synonymous with masturbation.

** The words enclosed in parentheses refer to Ego attitudes and trends arising on the basis of Id impulses.

3. Polyvalent	16	-21
4. Monovalent	21	-
Maturity	21	-

In making a satisfactory adaptation to the environment, the young human being faces problems involving localization of pleasure-giving zones to areas useful to the adult and race, finding an object external to the individual through whom the function of reproduction may be carried out, and redirecting the excess energy away from the primary function of reproduction and making it available for other purposes in the struggle for existence.

References:
(J)—pages 18-51.
(K)—pages 20-29.
(P)—pages 15-307.
(H)—page 110.

LECTURE NO. 5

The oral and anal stages:

Oral stage:

1. Stimuli on newborn child:
   a. External.
   b. Internal.
2. Response to stimuli.
3. Learning of first year:
   a. Gratification by sucking.
   b. Gratification by biting and chewing.
4. Psychological requirements of this period.

Anal sadistic:

1. Factors involved.
2. Relationship to mother.
3. Development of super ego.
4. Important behavior concepts established.
5. Concept of ambivalence.

At birth, the child is exposed to two groups of stimuli which cause discomfort, inducing him to use his energy in their removal to regain a tensionless state. *External* stimuli include cold, light, loud noises, changes in skin humidity, etc.; while *internal* tensions are those arising from his inner physiological needs. Arousal of instinct causes a production of energy which seeks an outlet; if there is no outlet the individual feels fear, directly proportional to the unexpended energy; whereas fear is lessened by an effort to expend the energy.

Through this process the ego becomes aware of one of the salient principles of life: discomfort or danger will cause fear unless the individual directs his bodily energy toward removing the cause or himself from the vicinity. The oral stage of development is touched on briefly, constituent parts pointed out, and the necessity that this stage be traversed without the child being too frequently unsatisfied or too abundantly treated. Anal-sadistic stage is described as the stage of infancy wherein bowel and bladder control is being gained and the child experiences the variable feelings of the parents regarding his excretory activities. He must learn to control some of his instinctive pleasures to meet the demands of the mother.

The process of toilet training lays the basis for certain important behavior concepts to come later: (a) to please the loved one, we must give to the loved one, relinquishing possessions we would like to retain. He may take over a hostile mother's attitude of dislike and repudiation of the value of his gift and come to consider it worthless or contemptible. He learns gifts can be given to express derision and antagonism; that is, he can retaliate to the mother by giving his gift in inappropriate places. The child may develop a feeling he is more powerful than the mother, and that he can master her by anal activities.

The instinct of aggression thus becomes connected with anal functions. The child is now faced with opposing feelings in that he can love and hate the same person at the same time. He may become ambivalent. For his future development it is important these conflicting feelings and opposing activities be synthesized and that the ambivalence be replaced by true object love unmixed with hate; that part of the hate be changed to aggressive activity toward the love object in order to possess and master, part be changed to aggressive activity tempered with sympathy and understanding toward other human beings, and part be changed to aggressive action against the dangers and difficulties of the physical world. The method of toilet training has farther-reaching consequences than the attainment of cleanliness, because so many important ideas are connected with it in the child's mind; therefore the methods used by the parents are important in the formulation of his super ego and ego reaction pattern.

References:
(H)—pages 168-189.
(J)—pages 21-35.
(K)—pages 21-25.
(P)—pages 15-70.

LECTURE NO. 6

The genital, latent, and adolescent stages:

1. Displacement to genitals.
2. Oedipus complex (parental rivalry).
3. Latent period.
4. Adolescence.

The importance of the genital stage of psychosexual development during the pre-school years, and its effect upon later personality formation, are discussed. In this the *oedipus conflict* is described in essence as a libidinal striving taking the form of unconscious desire for sexual satisfaction with the parent of the opposite sex.

The latent period, the period of beginning educability, with the repression of desire for the parent of the opposite sex and the sublimation of aggressive impulses toward the father being the psychological basis for combative games with playmates in the boy and this same process in the girl manifesting itself with playing house, with dolls, etc., continues the normal development of the individual. Two new situations confront the child, dealing with the school and teacher, an authoritarian father figure, and with playmates and other children. His reactions will depend largely on how his relations with his parents were, and upon what modes of behavior he adopted in dealing with them.

The stage of adolescence, beginning with the prepubertal period and encompassing the marked expansion of the sexual instincts, is discussed both from the normal and the pathological view. The possible retreat of the libido from genitalization to earlier stages in the face of a strict Super Ego is pointed out, as are the difficulties which develop from inadequate early genitalization, wherein the child becomes self-centered, seclusive, lacks interest in the outside world, etc. The ego's mechanism of relieving Id tensions through allowing direct expression, towards objects permissible to the Super Ego, and by changing the mode of expression, is discussed. The adolescent anxiety resulting from attempts to close all outlets to particular impulses is related to earlier feelings of anxiety. The development of reaction formation whereby Id impulses are expressed in behavior exactly opposite to their direct expression is also discussed.

References:
(J)—pages 44-51.
(K)—pages 25-26.
(P)—pages 71-307.
(R)—pages 74-113.

LECTURE NO. 7

The unconscious, pre-conscious, and the conscious:

Unconscious:

1. Definition.
2. Main attributes of unconscious (Freud).
3. Jung's views.
4. The content.
5. Reason for a belief in a dynamic unconscious.
6. Chief advantages from accepting the dynamic concept.

Pre-conscious:

1. Definition.

Conscious:

1. Definition.
2. Content.
3. Dissociation of consciousness:
   a. Normal.
   b. Abnormal.

The unconscious is that vast quantity of mental life which either never was in consciousness or, previously in consciousness, has been repressed. The elements are active constituents of mental life. The somatic and emotional effects are more powerful than those emanating from consciousness. It is dynamic and capable of affecting conscious ideational or emotional life without the individual's being aware of this influence. Jung sees the unconscious as consisting of both a personal unconscious and a collective or racial unconscious. The unconcious contains mental processes entirely beyond the realm of voluntary recall. It is the reservoir of past experiences of the individual, having begun shortly after birth of the person and continuing to grow with him.

Reasons for believing in a dynamic unconscious are: the post-hypnotic carrying out of suggestions held in the unconscious; the evi-

dences found through discovering the latent meaning of dreams; the discoverable bases for common slips or errors of speech, memory, and action; the small amount in consciousness at any one time in comparison to the latent content of the mind.

The advantages to be derived from acceptance of this concept are: an understanding of what the individual may be trying to express by his behavior; an understanding of the causes of various forms of behavior; and understanding that the difference between the normal and abnormal mental processes is quantitative in nature, and an understanding of the forms of psychotherapy which may advantageously be employed in a given case.

The pre-conscious is defined as that part of mental life which in appropriate circumstances, either through an effort of the will or stimulated by an associated idea, can be brought up into consciousness.

Consciousness is that part of mental life proportionately infinitesimal of which the individual is aware at any given time. It represents the upper stratum of life. It developed later to meet the demands of adaptation to the external, real world. It includes only those mental processes concerning which there is awareness at a given moment. Normally, consciousness is an invisible whole or stream of thought toward a given end. It can be broken up into independent fragments not coordinated to common ends. This is called dissociation of consciousness. This may be normal when it is temporary, partial in nature, and under the control of the individual, to be abandoned at will. It is abnormal when these latter criteria are not met.

The Id is entirely unconscious, the ego is largely unconscious but includes pre-consciousness and consciousness, the super ego includes consciousness, the pre-conscious, and a large portion of unconscious material, and has direct access to the Id. The ego constitutes the greater portion of the personality's contact with the outer world, although the super ego participates in this.

References:
(D)—pages 35-39.
(H)—pages 22-57.

LECTURE NO. 8

The fundamental problem of life:

1. Fundamental problem—adjustment to the environment.
2. Goal of behavior—*peace of mind.*
3. Peace of mind:
   a. Happiness.
   b. Love.
   c. Self-esteem.
4. Personality-Environmental struggle:
   a. Three fundamental urges:
      (1) Self preservation.
      (2) Race preservation.
      (3) Communal preservation.
5. Factors bearing on Personality-Environmental struggle:
   a. Constitutional.
   b. Developmental environment.
   c. Precipitating:
      (1) Emotional deprivations.
      (2) Threatened insecurity.
      (3) Physical or physiological causes.
6. Introduction of conflict.

The fundamental problem of life which all individuals face is that of adjusting to the environment. The environment includes more than the physical surroundings, for it involves all those things which go to make up a person's life situation. It is through solution of this fundamental problem that the individual seeks to attain the goal of all behavior, which is peace of mind.

Peace of mind has three constituent parts: happiness, in which there must be an element of hope; love, wherein the individual must feel security, that he is wanted, cared for and will be protected; and self-esteem, wherein he must feel no persistent doubts regarding his own capabilities. The individual who solves his problems so as to attain these three components attains the primary goal, peace of mind, and would be considered well adjusted to his environment.

In the personality-environmental struggle, the three fundamental urges are as given. Of the factors bearing on this personality-environmental struggle, the constitutional factors are probably less important than the developmental-evironmental factor. In the latter, the good or bad results of emotional relationships, train-

ing, and education predispose to good or poor capacity for adjustment. Freud has said that a child who is loved by his mother until he is 5 cannot help but be a success. The child's attitude toward men and women is conditioned by his early attitudes towards his parents. The details of his early developmental period are important in the diagnosis, prognosis, and treatment of possible later difficulties.

In this early period, he learns to be trustworthy or deceptive, to love or to hate, to be dependent or independent, lazy or industrious, uncomfortable or at ease with people. The precipitating factor is seldom the real cause of the mental reaction. The margin of tolerance varies markedly with different individuals. In the functional mental illnesses the causes are often internal stresses brought to light in the form of symptoms. These come from emotional deprivation, parental rejection, lack of approval, recognition, parental love, ego gratification, etc.

There may be threatened insecurity in new situations, changes of jobs, moves, promotions; and there may be physical or physiological causes such as exhaustion, exposure, injury, systemic diseases, etc. These factors introduce a situation called conflict in the personality versus the environment struggle. This includes the conscious and the unconscious wants, vs. what the individual can have or can get. Frustration of instincts and difficult conformation to herd tendencies are particularly frequent in military environment. Many conscious conflicts are solved readily every day, though the decisions are often made on a basis unconscious to the person.

References:
- (K)—pages 30-39.
- (Ó)—pages 13-40.
- (S)—pages 16-21.
- (U)—pages 13-16.

LECTURE NO. 9

The solution of conflict:

Unconscious conflicts:

1. Ambivalence.
2. Direct compensation.
3. Around sex.

Cultural conflict:

Chief sources of internal stress in military environment:

1. Emotional deprivation.
2. Threatened insecurity.
3. Physical burdens.

The solution of conflict:

1. Definition of complex:
   a. Conscious or unconscious.
   b. Emotional, not logical thinking.
   c. Psychic energy involved.
   d. Emotional tone troublesome and repressed.
   e. Disproportion between stimulus and reaction.

Mental anguish:

1. Tension.
2. Deprivation or frustration—results in aggression.

Mental mechanisms:

Complexes:

1. Good and bad.

Conflicts may be conscious or unconscious, and there may be a conflict between conscious desires and other unconscious, incompatible desires; between reality, ideals, morals, etc. Ambivalence is often a factor. There may be a discrepancy between one's ideal picture of oneself and one's own past deeds. These conflicts may affect one's behavior. Certain cultural conflicts exist between inconsistent or conflicting trends. Among these are man's attitude towards women, towards women doctors, towards a wife's career, towards killing, towards sex, etc. Strong, flexible characters can and do adjust; the weaker ones are apt to crack under the strain.

In a military environment, some of the chief sources of internal stress are separation from home, new occupations, increased responsibilities, physical fatigue and exposure, the impersonality of the environment, regimentation, loss of personal liberties, accountability for behavior, and anticipation of injury or death. These all fall under either emotional deprivation, threatened insecurity, or physical burdens. A conflict involves persistent, automatic attempts at solution. The psychic energy associated with a desire for gratification, threat to self-esteem or fear of injury, when denied an outlet, results in mental anguish, exaggerating the demand for solution.

Complex is defined as a group of related ideas vivified by strong emotional tone and demanding expression in consciousness. The action is

related to the amount and kind of emotion present, and these complexes may be manifest by character traits, slips of the tongue, mannerisms, and forgetfulness. They may be conscious or unconscious; they involve emotional rather than logical thinking; there is usually a marked disproportion between the stimulus and the reaction.

When a biological threat or danger faces the organism, tension results, and the autonomic nervous system responds either with a fight or a flight reaction. Tension is always present in a waking state and is manifest as tonus, or the ability or readiness to react. A psychologically sick person shows tension out of proportion to the apparent problems facing him. His problem, however, may be unconscious to him. Chronic tension wears one out somatically.

With deprivation or frustration, either partial or complete, aggression results. This may be direct, against the frustrator, or indirect, against a symbol. With the aggression, there is accompanying fear and anxiety. To rid himself of the mental anguish and in response to its dynamic urges, he attempts to solve the conflict. The mental procedures or processes employed in this solution are called mechanisms. As the goal is peace of mind, these mechanisms may be thought of as a procedure by which the individual strives to adjust to his environment.

Complexes may be either good or bad. The former accomplish something useful and are associated with such things as patriotism, family honor, politics, religion, and hobbies. Bad complexes are ones which have a destructive effect on the individual or environment.

References:
(K)—pages 122-151.

LECTURE NO. 10

Mental mechanisms:

1. Definition and purpose.
2. Types:
   a. Daydreaming (fantasy).
   b. Rationalization.
   c. Compensation.
   d. Sublimation.
   e. Projection.
   f. Identification (introjection).
   g. Displacement.

By *mental mechanisms* is meant the habitual manner in which an individual works out his problems, what he does when confronted with difficulties and mistakes. Mental mechanisms not only shape the functional symptoms but disguise their real purpose. Through mental mechanisms the individual rids himself of unpleasant emotional tone or mental pain arising from the dynamic urges of the conflict. The object of solution is to obtain peace of mind. Mental mechanisms may be thought of as means of striving to adjust to the environment.

" . . . *abnormal* mental mechanisms differ in kind very little or not at all from the *normal.* The same mental processes are observed in the socially well-adapted person as in the maladjusted psychoneurotic. It is considerably more a matter of degree."

Among the types of mental mechanisms employed in the solution of conflict are:

1. Daydreaming or fantasy formation.

2. Rationalization, or the necessity for finding a reason or explanation for every phenomenon. This has been called *self-deception through adventitious reasoning.*

3. Compensation, an attempt to make up for real or fancied deficiencies by appropriate alterations of thought or behavior (this may be conscious and deliberate as well as unconscious and automatic).

4. Sublimation, a mechanism by which energy from undesirable or unattainable ideas or desires is drafted off into a channel which is thought not undesirable or unattainable, or a redirection of energy.

5. Projection, wherein one condemns in others faults to the commission of which one himself has a conscious inclination; seeing one's own faults in others without recognizing them to be our faults.

6. Identification, whereby the individual identifies himself with another individual, real or imaginary, in order that he may derive strength from the other individual to help him attain certain unconscious desires. Awarding ourselves someone else's virtues.

7. Displacement, wherein the emotion arising through conflict is transferred to another person or object by substitution.

References:
(D)—pages 42-68.
(S)—chapter 5.
(T)—pages 91-100.
(V)—page 705.

LECTURE NO. 11

Psychiobiology and psychobiological constitutional and reaction types:

1. Origin of the concept of psychobiology:
   a. Definition.
   b. Subject matter.
2. Comparison with other schools:
   a. Freud.
   b. Adler.
   c. Jung.
   d. Behaviorist.
   e. Gestalt.

The concept of psychobiology was introduced by Adolph Meyer and regards the individual as a whole or functioning unit, any part of which may break down and influence the functions of the total individual. It views the individual in the long section of life, taking into account all important life happenings, somatic and emotional. It is the science of personality function. According to Meyer, it is the science of understanding how and why the integrated unit or person made up of organs and parts works together, not in the sense of a mere summation of parts and part functions, but as an integrate in inter-relationship, to produce what we call a live man, capable of living, growing, reproducing, acting, talking, feeling, understanding, remembering, anticipating, having desires, ambitions, special appetites and traits, which single him or her out as a particular one of the zoological entities specified by the term *man*.

Psychobiology deals with the meanings of things in the life of a person. It notes the occurrences of the life history and makes an estimate of their significance in producing a psychoneurotic or psychotic maladjustment.

Freud reached the conclusion catharsis was sufficient. Free association developed into psychoanalysis. He felt psychic phenomena were uniformly present, determined by the individual's mental motives, even though out of awareness. He postulated the *unconscious* by reason of his findings in free association, mistakes, and dreams. He also introduced the concept of repressed infantile sexuality.

Adler postulated organ inferiority, and developed the idea that most emotional disorders grow out of a striving for power, indulged in an effort to compensate for feelings of inadequacy and inferiority. He felt neuroses were all on a basis of inability to meet goals, a face-saving dodging of social responsibility.

Jung introduced analytic psychology and the concepts of the personal and collective or racial unconscious. He felt neurosis was a failure in an attempt at adjustment to life, and that symptoms resulted because not all of the naturally adaptable materials were used. He laid the groundwork for the ideas of Introvert and Extrovert.

The Behaviorist School of Pavlov and others was wholly objective, threw heredity to the winds, developed a stimulus-response psychology, disallowed the subconscious.

The Gestalt School dealt with configuration and contrasted the meaning of an idea with its structure and content. It advanced the concept of the human brain as an energy system possessing the power of will, and held that the whole is not built by coordination of parts, but that parts are derived by differentiation or individuations from the whole.

Psychobiological constitution and reaction types is a study of the relationship between human form and human nature. Sheldon's classification of endomorph, mesomorph, and ectomorph is undoubtedly familiar to readers. Kretschmer's classification of the pyknic, asthenic, athletic, and dysplastic physiques is also well known. Sheldon classified temperament as viscerotonic, somatotonic, or cerebrotonic. These classifications may be related in that asthenic or ectomorph is by personality more often schizoid, introvert, and cerebrotonic, and tends towards anxiety or schizophrenia if mental illness develops; whereas the phynic or endomorph, cycloid, extrovert, viscerotonic tends toward hysteria and manic depressive disease if mental illness develops.

References:
(D)—pages 69-93.
(S)—pages 29-32.
(T)—pages 9-25.
(X)—pages 4-48.

LECTURE NO. 12

Broken personalities:

1. Somatic type (physical illness personalities):
   a. Physically crippled personality.
   b. Illness-prone personalities.
   c. Diseases with first symptoms physical; later, disorders of perception, thinking, feeling, behavior.
2. Hypophrenic (stupid) personalities.
3. Isolation type (lonely) personalities.
4. The schizoid type—queer personalities.
5. The cycloid type (moody personalities).
6. The neurotic type (frustrated personalities).
7. The anti-social type (perverse personalities).

The core of the human personality is constitutional, and largely genetically determined. This can be influenced environmentally, and life's experiences may be thought of as building stones which go into the construction of the completed personality. Building is never finished, however, since this is a dynamic process continuing unto death. The degree of mental health depends both on the constitutional core and the way life's experiences are built into the structure.

In our dealing with people as adults we are prone to categorize individuals into certain type of personality. Menninger, in his text "The Human Mind," has given a practical and descriptive outline of the personality types which are prone to have unusual difficulties under adaptational strain. It is important that the Flight Surgeon recognize these various types of personality. Menninger, in his text deal appropriately with each type as he serves his group.

First is the somatic type, or physical illness personality, who gives somatic evidence of his psychological difficulties. Various sub-types are recognized, including those prone to asthma, constipation, peptic ulcer, hypertension, etc. A second type which will have difficulties in adaptation is the hypophrenic, or stupid personality. These individuals of limited intellectual capacity can succeed only under favorable conditions. They frequently get caught for crimes smarter people get away with; they are prone to follow simple, though tedious, tasks.

Ninety percent of these people are peaceful, law-abiding citizens. A third type, the isolation, or lonely personality, is marked by seclusiveness, eccentricity, unsociability. Some of these are the temperamentally unsocial who prefer to be left out of things; and others are the wistful outsiders who long to enter social activities and either don't know how or are held back by fears. These people rate particular attention from the flight surgeon. A fourth type, the schizoid or queer personalities, show a common tendency, their inability to get along well with other people.

By sub-types, they may be the seclusive, the hardboiled, the artistic, the grouchy, or the radical. Their adaptation is particularly difficult. A fifth type, the cycloid or moody personalities, are those who show mood swings not provoked by the environment. In the up phase, they do a prodigious amount of work, are full of pep, and often participate in fistic or legal fights from encountering unsuspecting irritants about them. In the down phase, they show no interest, no enthusiasm, are apathetic, self-deprecatory, are in need of help.

Another type, the neurotic, or frustrated personalities, are those whose childhood development was such that the conflicts between their instinctive tendencies and the environment were never resolved in a way wholly satisfactory to the ego, and who are therefore constantly impelled to indulge in behavior which gives them a needed satisfaction at an exorbitant cost.

This type always contrives to defeat its own aim, to spike its own guns, and lay its own pitfalls. Their primitive sexual and aggressive instincts have been modified to meet social requirements only with painful difficulty. Indecisiveness is marked. They substitute neurotic symptoms for instinctual gratification. Another type, the antisocial or perverse personalities, are those often called psychopathic personalities. *Perverse* is a good word. These people play at the game but break the rules. Their defectiveness is in their emotional and volitional functions; they cannot keep out of trouble. Rather than symptoms, they show behavior abnormalities, and the environment suf-

fers. They may be troublesome, even dangerous; yet they themselves suffer worst of all. They have no place in naval aviation.

References:
(A)—pages 34-158.

LECTURE NO. 13

Psychosomatic relationships:

1. Definition of psychosomatics.
2. Effect of emotions on structural changes.
3. Emotional contacts and exposures.
4. Commonest emotional components of structural disease:
   a. Infantile reactions (regressive in nature).
   b. Repression of hostility.
   c. A stepped-up pace of life.

In association with this lecture, a movie is shown which beautifully illustrates the influence of emotions on bodily function and vice versa. All emotional reactions have certain physical accompaniments. With fear, tachycardia, palpitation, nausea, vomiting and other symptoms result.

Similarly, a physical sensation such as severe acute abdominal pain results in the emotional manifestation of apprehension or fear. An individual cannot be sick only in body or only in his mind. This relationship between mind and body is a constant and dynamic one. Psychosomatics is a point of view rather than a body of knowledge. We must abandon the dualistic concept that the disorder is either functional or organic.

Terminology may often be a straitjacket to our thinking. An aviator who is frustrated by his responsibilities and tasks, and who generates excess acid may develop acute abdominal pains and eventually get enough erosion of the gastric mucosa to produce an ulcer. If we diagnose this *peptic ulcers*, we automatically think of treatment by diet, powders, or surgery. If we formulated the case into the total person terms, we might appropriately think of management by changing the job situation or reducing the emotional tension. A diagnostic formulation such as "worry over job, fear at competition, panic at jeopardy of his status and living standards resulting in excess gastric acidity" would be more helpful in our thinking than a simple diagnosis of ulcer, although admittedly no hospital record committee would accept it.

We must understand that emotions can and do produce structural changes through affecting the tonus, secretion and circulation of tissues and organs. If we admit that a single severe emotional experience can produce a transient rise in blood pressure, why can't we accept the thesis that nagging, prolonged frustration can and does produce a prolonged or permanent hypertension.

We must also recognize the result of emotional contacts, particularly in the early developmental years of an individual's life. Later emotional exposures are also important. One man is exposed to the bacteriological trauma of a roommate with active tuberculosis; whereas another man has a roommate with heart disease, who lives in constant contemplation of sudden death. Certainly both are real exposures.

The commonest emotional components of structural disease are: (a) infantile reactions (regressive in nature); repression of hostility, and (c) a stepped-up pace of life. The doctor must be able to assay the environmental forces acting on his patient and be able to manipulate these for the patient's welfare. He must also be able to modify the patient's own goals, ambitions, and demands in a realistic way.

References:
(Y)—pages 251-277.

LECTURE NO. 14

Events which precipitate a neurosis; and emotions and their effect on the body.

Crises at which vulnerable personalities tend to break down:

1. Puberty.
2. Leaving school.
3. Love affair.
4. Marriage.
5. Bearing or fathering a child.
6. Vocational or financial disappointments.
7. Loss of a loved one.
8. Threats from environment.

AGE OF ADULT NEUROSIS

Nature of adult deprivation:

1. In single people.

2. Married women.
3. Married men.
4. Financial insecurity.
5. Need for aggression.
6. Disappointment in loved object.
7. Career women.
8. Discussion regarding real illness and neuroses.
9. Appendix removal.
10. Approach of involutional period.

There are crises in every life, and at these points the vulnerable personality tends to break down. (See outline). In the past we have been prone to think of a neurosis as resulting from a major catastrophe. It is true that such events may precipitate a neurotic outbreak, but many begin without any such event in close relation to the onset. It is usually a culmination of events and forces, often difficult to piece together, which precipitated the final break.

Most adult neuroses break out between late adolescence and 35 years of age, when in a period of increasing responsibilities an effort is being made to establish oneself socially, economically and with his sexual instincts. This is a period with frustrating and disappointing experiences, many of which are similar to the original ones in childhood.

In single people, a neurosis may occur gradually following a second marriage of a parent. This may reawaken and disappoint an oedipal attachment. Married women may gradually develop a neurosis when their fantasied desires in marriage are not fulfilled. Some women expect the impossible in marriage. When they can verbalize their feelings, they often realize that their partner is not enough like some childhood image, usually the father.

An unwanted pregnancy may lead to anxiety, depression, and G. I. symptoms because the patient is too psychically immature to want a child. At a deeper level, it may represent a long-desired yet feared competition with her mother and arouse much guilt. A married man may become neurotic because his wife is not enough like the mother, because he cannot have the dependent role he wishes as he is temporarily dislodged from his wife's affection by the birth of a child, or by slow failure to reach a desired goal or a position of prominence which is seen unconsciously as a thwarting from a superior.

The human psyche is not an area of harmony; it is a continued battleground of conflicts and trends, mostly from the dynamic instincts of sex, self, and herd. Usually the respective demands are in conflict with each other and are often irreconcilable. The friction of emotional conflict cannot be continued forever, nor can it remain in status quo. The emotional cross-purposes must be relieved or compromised, even if the compromise be a pathological one. Every pathological solution of the emotional conflicts gives rise to psychoneurotic manifestations.

Basic patterns of emotional conflicts are endlessly repeated, filled with disappointments, marital difficulties, rejections in love life, economic reverses, etc. These and many other life situations tend to bring on anxiety, which over a long time takes a heavy toll of the mental resistance and often disrupts the personality.

In aviation medicine, having decided the illness of an individual is psychosomatic, the flight surgeon's next step is to locate the source of emotional difficulty. Sometimes it is apparent in the life situation of the patient; at other times it is not so simple and may lie buried in the unconscious of the patient, who will not know anything about it except as it produces a chronic feeling of uneasiness or anxiety. The flight surgeon may then rightfully refer the patient to a psychiatrist.

References:
(J)—chapter 14.
(S)—pages 18-21.
(X)—pages 511-529.

LECTURE NO. 15

Neurasthenia:

Outstanding complaints:
1. Fatigue.
2. Somatic discomforts.
3. Mild mood disturbances.

Objective findings.
Etiology and structure.
Illustration of investing objects with libido.
Differential diagnosis.
Prognosis.
Treatment and management.

Neurasthenia is a term of Greek derivation, literally meaning lack of nerve strength, first used by Beard in 1869. It now has a more limited meaning than formerly, although all

psychiatrists do not agree on its being a separate entity. Generally it covers the three outstanding complaints of fatigue, various poorly defined somatic discomforts, and mild mood disturbances. The fatigue is the most constant and usually the first symptom mentioned. It may be tiredness after minimal exertion or constant fatigue independent of exertion.

It makes him think himself organically ill. The somatic discomforts are many and varied, may be recited glibly, and include palpitation, anorexia, post-prandial discomfort, gas formation, constipation, headaches, sensation of pressure on top of the head, a bandlike constricting sensation, dizziness, spots before the eyes, etc. The most common mood distubances are irritability and mild depression. Patient is gloomy, introspective, unable to concentrate. He lacks self-confidence; problems in the sexual sphere are common, including impotence, frigidity, and disgust, all of which are indicative of general maladjustment of the love life of either sex.

The objective findings include loss of weight, low blood pressure, vasomotor lability, the mood reflected by the facies or posture; while examination of the body systems reveals normal function. The etiology is defective personality development permitting conflicts. While overwork has been blamed, we rarely find a neurasthenic who is ever overworked. Those who do not accept psychogenic origin seek some somatic or organic pathology to explain what is seen, and often pounce upon some minor deviation and over-treat this, with no result save discouragement for the patient and the doctor.

What is the etiological structural pathology in neurasthenia, or how do we get the presenting complaints? We recall that in the discussion of libido development, we recognized the infant's early interest in himself. Later, after the narcissistic stage, comes an interest in others, which is more or less sexually tinged. The interest and sexual component cannot be separated successfully; consequently if the sexual interest is frowned upon, rejected or punished, it finds only limited gratification in these love objects and returns with itself.

With curtailment of outside interests, self-interest grows proportionately; and this fact of self-preoccupation has long been stressed in the neurasthenic. When the capacity to choose, or no desire to choose an external object exists, the fantasy life absorbs libido, resulting in inactivity, poor concentration and dissatisfaction. Perverted organ function, fatigue, and symptom formation may result. Added tension comes from the frustration and self-preoccupation. The individual feels vague needs are unsatisfied.

A differential diagnosis must include psychotic depression, schizophrenia, early paresis, early arteriosclerosis, early tuberculosis, hypothyroidism, various blood dyscrasias, ulcer, neoplasm, and, rarely, Addison's Disease.

Once the diagnosis of neurasthenia is made, we must recognize we have a serious problem. The prognosis is variable. It is better in acute cases with a sudden appearance of symptoms. In longer standing cases, treatment is much more difficult. Certain neurasthenias approach psychoses in psychic structure. The most suitable treatment is probably psychoanalysis. When this is impossible, less intensive psychotherapy along the lines of recognition that no infectious or structural changes exist to account for the symptoms, that the difficulties exist in the psyche and that concentration upon these problems may result in improvement, is taken. The more the patient can be helped to see where emotional satisfactions are to be gained in the outside world, the less psychic energy there is left to stagnate in the body to produce discomfort.

References:

(A)—pages 138-141.
(F)—page 32.
(J)—pages 194-208.
(X)—pages 534-540.

LECTURE NO. 16

Anxiety Hysteria:

Anxiety hysteria:

Types.

1. Primary.
2. Ego.
3. Mutilation.

Clinical manifestations:

1. Sudden feeling of discomfort and apprehension.
2. Somatic manifestations.

Phobia.

Etiology and psychopathology.
Differential diagnosis.
Prognosis.
Treatment:
1. Psychoanalysis.
2. Primary requisites:
   a. Knowledge of the structure of neurosis.
   b. Time.
   c. Cooperation on patient's part.

This is probably our most common neurosis today. The three types of anxiety are: primary, or the anxiety incident to psychic helplessness in early life; ungratified hunger needs lead to this anxiety. Ego anxiety occurs later, when the life situation threatens a return of early psychic helplessness. Mutilation anxiety, or fear of bodily harm, is a retaliation for aggressive fantasies of a sexual or other nature. This awakens early fears based on the childhood belief in retaliation.

The clinical manifestations include a sudden feeling of discomfort and apprehension, intense mental suffering, sometimes definite fears of insanity or impending death. Somatic manifestations include palpitation, sweating, dizziness, dyspnea, trembling, nausea, "terrible all-gone feeling," etc. These may occur either night or day. They are very incapacitating; attacks last a few minutes with gradual subsidence. The patient gradually modifies his activities in such a way as to attempt to avoid the attacks. This attempted avoidance is termed a phobia. Some common phobias are fear of going alone in the streets, fear of crowds, of riding in public conveyances, of closed spaces, open spaces, of dirt, etc. These enlarge to increasingly curtail healthy activity.

If primary anxiety in the infant is too frequent or too overwhelming, unconscious memories of it remain to show themselves later when the individual perceives a warning of impending helplessness. Early childhood disappointments and frustrations lead to aggressive hostile fantasies which stimulate a fear of retaliation or punishment, and anxiety results. Every adult anxiety hysteria is considered a replica of a childhood experience. The phobia projects an inner danger outward, so that the ego is in the middle, between the dangers of instinctual demands and the dangers of the outside world. The unsolved oedipus complex is considered the kernel of the neurosis, in that the child's fear of the dreaded rival parent is displaced, so the child can go on living with and loving the parent by avoiding the substitute. It is important to realize that the phobias are in themselves results of the process of substitution, and that one must look beneath the surface for the causative agent.

Anxiety hysteria must be differentiated from a cardiac crisis, G. I. dysfunction, and schizophrenia. Some familiarity with the syndrome will make it readily recognizable. The prognosis is not as good as for conversion hysteria, but better than neurasthenia. The earlier in life it is treated the better. These patients are very adept at self-defense. The prognosis depends on the length of time the attack has been going on and the skill of the physician.

References:
(R)—pages 193-215.

LECTURE NO. 17

Conversion hysteria:
Symptomatology:
1. Sensory phenomena.
2. Motor phenomena.
3. Convulsive seizures.
4. Visceral phenomena.
5. Vasomotor disturbances.
6. Psychic phenomena.
7. Somnambulism.
8. Dual personality.
9. Hysteric catalepsy.
10. Hallucinations.
12. Occupational neuroses.
13. War neuroses.

Etiology and psychic structure:
Psychological occurrences in genesis of attack.
Differential diagnosis.
Prognosis.
Treatment.

There are few symptoms of organic disease that this complex medical entity cannot simulate. It was one of the first neuroses to be studied widely, and the French school, including Charcot, Bernheim, and Janet, worked intensively with hysterics. Mood and character changes as well as physical or somatic alterations are prominent. Traumatic neuroses or

traumatic hysteria, which were loosely called war neuroses, are important to the flight surgeon. Shellshock, concussion neuroses, exhaustion neuroses, etc., belong in this category. It is difficult to evaluate the results of actual tissue injury and the results of fear, fright, and threat to the organism's integrity. In these so-called traumatic neuroses, there is a preponderance of headache and dizziness, with mental symptoms of headache, depression, and impairment of memory.

Terrifying dreams may occur. Often an element of compensation plays a large role in the continuation of symptoms. One sees many cases where seemingly more could be gained by getting well than by holding out in this way for compensation; yet the patient prefers to overlook his future adjustment and tends to concentrate too much on the immediate problems of restitution.

Charcot called hysteria a psychosis produced by ideation and responding to suggestion. It is not currently considered a psychosis but rather a neurosis, and it was Freud who showed the importance of unconscious conflicts and of early sexual trauma. He considered it the distorted expression of unconscious mental conflicts, the symptoms being attempted defenses against instinctual desires which threaten to break through.

The character of the hysteric is infantile. The patient demands a great deal of attention, and is sensitive to the necessary daily frustrations of life. He has feelings of inferiority, a great craving for expressions of love, is changeable in his affections, and lacks the capacity to love in an adult, altruistic way. He is an open personality who can quickly make friends, even strong attachments, but eventually his friends disappoint them, since their demands are so great.

The psychological occurrences in the genesis of the attack are, according to Pearson and English:

1. Deprivation with resulting anxiety.
2. Introversion or withdrawal of libido and failure to retain contact with the environment and maintain relationship with people.
3. Regression to earlier mode of reaction.
4. Return of the repressed oedipal wishes.
5. Symptom formation as the solution of conflict.

In differential diagnosis, a suspicion that hysteria exists should not preclude any reasonable examinations that would reveal organic disease. One distinctive factor in hysteria is *la belle indifference.* The prognosis, while good, still must recognize that a disturbance in the personality of considerable magnitude exists. Treatment may be lengthy, and to be successful must depend largely on understanding the forces at work in the condition. Modification of the environmental conditions, plus modification of the patient's attitude, is essential.

References:
(J)—pages 210-237.
(K)—pages 47-54.
(R)—pages 216-235.
(X)—pages 540-560.

LECTURE NO. 18

Psychopathic personality:

Cause.

Distinction from other personality disorders:

1. Psychoneuroses.
2. Mental defective.
3. Ordinary criminal.

General picture:

1. Superficially attractive.
2. No irrationality, marked nervousness, or other symptoms of psychoneurosis.
3. No sense of responsibility.
4. Total disregard for truth.
5. Accepts no blame—employs mechanism of projection.
6. No sense of shame.
7. Offensive conduct without apparent cause.
8. Lack of interest in financial success.
9. *Most outstanding trait—inability to profit from experience.*
10. Egocentricity.
11. Poverty of affect.
12. Lack of insight.
13. Alcoholic indulgence—peculiar pattern.
14. Peculiar sex life.
15. Not prone to suicide.
16. Inability to follow life plan consistently.
17. Striving for failure.

Borderline psychopathic personality:

1. In Naval service.
2. In aviation medicine.

Psychopathic personality in the military service.

This is a vague diagnostic category covering

a wide variety of maladjusted people who cannot be classed either as psychotic or psychoneurotic, but who do have inadequacies of personality structure resulting in their being socially maladjusted persons. When lifelong abnormal behavior is antisocial, egocentric and unaltered by experience, the diagnosis of *constitutional psychopathic inferiority* is appropriate; whereas if the outstanding characteristics are not primarily antisocial, but rather those of inadequacy coming on around adolescence, the diagnosis of *personality disorder* is more appropriate. The psychopath exhibits a particular type of emotional immaturity, with strong drives for immediate satisfactions and pleasure without regard for the future.

This condition must be distinguished from psychoneurosis, wherein, the patient is anxious, unhappy, or obsessed with thoughts he recognizes as absurd. The psychopath shows none of the usual neurotic picture, he tends to act out his conflicts, with resulting suffering and unhappiness for those in his environment, but with little conflict or guilt feeling. He is hard, in contrast to the sensitivity of the neurotic. The mental defective is obviously stupid, and his follies may be readily understood as resulting from his lack of intelligence; the ordinary criminal works consistently towards his own ends; the psychopath seldom takes advantage of what he gains, and almost never works consistently in crime or anything else to achieve prominence. The criminal's end can usually be understood by the average man. The psychopath's end is not so readily understood. His antisocial actions are incomprehensible and often for no material gain. His general picture is given in the outline above.

In the naval service, the borderline psychopath presents perhaps a greater problem than the true psychopath, particularly in regard to the magnitude of the problem. These people prove inadequate to the complete fulfillment of their duties and must be considered both by medical and disciplinary authorities.

The borderline psychopathic personality accounts for a large portion of our maladjustmenst in the naval service. Many of these maladjustments are incidental to the service and actually extend back years prior to entrance, resulting primarily from a personal inadequacy. In civilian life these people were sufficiently protected by their families, and their communities, to prevent serious difficulties in their daily routine. In service, they are deprived of this protection and immediately begin to experience difficulties. The majority are disloyal to any organization, are easily suggestible, and as a result are in constant difficulty. They lower efficiency and impair morale. They form a large number of absentees, the discontented, the inefficient, the inmates of the brig, and the frequent visitors to sick bay. They are useless to the service.

References:

(C)—all of this reference.
(D)—pages 504-520.
(X)—pages 495-510.
Article by Bloom in *Cosmopolitan Magazine*, February 1948 issue.

LECTURE NO. 19

The psychiatrist in a dispensary:

Psychiatry as a medical science really began in the latter part of the 19th and the early part of the 20th century, when such men as Kraepelin, Prince, Freud, Meyer, and White began their memorable contributions to the study of the human mind.

Thirty years ago, many first-class medical schools did not provide their students, internes, and residents with any systematic psychiatric training.

In the past three decades, there has been a rapid development and extension of the field of psychiatry. An important step forward was the child guidance movement beginning in 1920 under the influence of Dr. William Healey.

As early as 1909, the Surgeons General of both the Army and the Navy accepted the invitation of the Superintendent of St. Elizabeth's hospital in Washington, D. C. to assign medical officers to that institution for instruction and study. This was the beginning of graduate training in psychiatry for the armed services. Recognition must be given to Colonel Thomas W. Salmon, MC, U. S. Army, and to Dr. William A. White for their scholarly contributions to military psychiatry during World War I.

In the past 10 years, the field of psychiatry has made further progress, both in its contribution to the health of the nation and its acceptance by the general public. Psychiatry was placed on the same plane with medicine

and surgery by the military forces in the late war, and the opportunity was thus provided for psychiatry to take its proper place as a major member in the constellation collectively known as the healing arts. The establishment by the Veterans Administration and by our larger American cities of mental hygiene clinics to provide the necessary out-patient care to the emotionally handicapped veteran and the troubled citizen has been another step forward in the emancipation of the specialty from the cloistered State hospitals to the place it should have in the community.

Concurrent with the spread of psychiatry to the general public, there has been increased emphasis on prevention rather than custody, and therapy rather than diagnosis and disposition. With the appropriate shift in emphasis to prevention has come increased acceptance of the specialty by the public and a decrease in the hesitancy of the individual to seek psychiatric assistance.

Naval medicine has long provided competent, well-trained psychiatric personnel for the major naval hospitals, prisons, and training stations. The Navy has been ahead of its civilian counterpart in that almost all naval hospitals have had a psychiatric service as an integral part of the organization. The drive to have such a service in all large civilian hospitals is making progress, but much yet remains to be done to achieve this undeniably desirable goal. Keyes, Bookhammer, and Kaplan, writing in the *American Journal of Psychiatry,* August 1948, reported a study of the consultations done by a psychiatric service in a six-months period at the Jefferson Medical College hospital. They found that 81 percent of the patients referred for study consisted of psychosomatic disorders or psychoneuroses.

It is believed that in the large dispensary such as one finds at our naval air stations there is an even greater opportunity for service by medical officers trained in psychiatry than has heretofore been recognized. Captain Francis J. Braceland has pointed out that wartime experience in the field of psychiatry in the Navy showed that the neuroses and psychopathies in general made up more than 90 percent of the neuropsychiatric problem during the war; while hospitalized psychotics amounted to one per thousand personnel per year, and represented less than ten percent of the hospital psychiatric problem, to say nothing of the over-all psychiatric picture.

General Menninger, in discussing the Army's experience in psychiatry during the war, stated that the neuroses, psychopathic personalities and mental defectives constituted 93 percent of the admissions to hospital psychiatric services; and further stated that for every psychiatric patient hospitalized, three or more were seen in facilities other than hospitals for psychiatric help. He went on to point out that the vast majority of psychiatric cases seen in the Army were mild maladjustments and neurotic reactions; whereas the major portion of the civil practice had long been with psychotics.

Let us now look at the role of the psychiatrist serving outside a naval hospital. In any naval community, problems are constantly arising wherein psychiatric help would be useful. Among these, consideration may be given to the young enlisted man fresh from training camp who finds difficulty in integrating himself to service life. Many of these apparently maladjusted young men would profit from psychiatric study and counsel. In this manner the work of the personnel officer and the command may be lessened by the avoidance of the administrative problem the misunderstood misfit becomes as he fights his conflicts through irregular behavior.

Those obviously inadequate, inapt, immature, and those suffering from longstanding personality disorders which militate against successful service, can be readily identified and should be eliminated by administrative discharge. This saves both time and money for the service by avoiding unnecessary hospitalization.

Admiral Dallas G. Sutton, long active in the field of psychiatry in the Navy, corroborates this point when, writing in the *Naval Medical Bulletin,* he states: "Under normal conditions the loss of man days attributed to the study and hospitalization of psychiatric cases is very considerable." Many of the new men with adaptational problems are salvageable through understanding advice and proper placement. Personnel officers are quick to cooperate with the psychiatrist in these matters, for a well-adjusted man reduces their problems and con-

tributes to the over-all efficiency of the command.

Another field of service is with the psychosomatic illnesses. The concepts of inter-reaction of mind and body in the production of symptoms have long been established. Strecker, Weiss, English, and others state that from 50 percent to 75 percent of all patients appearing in the offices of the general practitioner have illnesses with a large emotional component. The experienced naval medical officer would readily agree that elimination of the traumatic cases would leave the percentage ever higher. These men come in with real complaints of illnesses known so often to be functional: headache, nausea, vomiting, asthma, diarrhea, epigastric pain, and certain skin conditions. They merit more attention than the brief encounters they sometimes get from the medical officer. Quickly-ordered and dispensed *standard remedies* do not always suffice in these cases. Many of these functional complaints can be relieved only by psychiatric treatment.

Marked improvement in efficiency and saving in manpower can be effected when such treatment is available. This is not to imply that all non-psychiatric medical officers are ignorant of the more common psychotherapeutic procedures; but in these days of understaffed dispensaries and harrassed, overworked medical officers, there is often not sufficient time available to handle such cases in the manner the medical officer himself may recognize as necessary. It is maintained here that the availability of a psychiatrist will enhance the quality of medical care, and at the same time improve the morale of the medical staff.

Another field for the psychiatrically trained medical officer is in the study of men facing disciplinary action. The responsibility for the punishment of the offender in the naval service lies with the command. More and more, commanding officers are showing not only their willingness but their desire to have these men studied by psychiatrists in an effort to determine the forces at work in their anti-social or delinquent behavior.

A life history from the longitudinal viewpoint, a psychometric and attitudinal study, and an estimate of the strength of the various forces at work in the personality will shed light on the conflicts of the man and his failing adaptation. Such information and advice to the responsible officer or court martial enables consideration of important and appropriate factors before action is taken. In a similar manner the psychiatrist can aid both the command and the individual patient in cases of suspected or actual sexual deviation and of alcoholism.

Still another area where psychiatric aid is necessary is in the care of dependents. These patients will be found to constitute a large part of the total number of patients served. They present problems which vary from requests for advice concerning "problem" children or marital maladjustment, through the various mild somatic and psychic manifestations of tension states, to the frank psychoneuroses and psychoses. Although it is the policy of the Navy to provide medical care for dependents of naval personnel, as yet no steps have ben taken to furnish hospitalization for psychiatric patients in this category. It is certain that the availability of psychiatric help can be an asset to the mental health of the naval community and prevent in some cases the actual personality disruptions which necessitate hospitalization.

Experience has shown that adaptation to the military environment, with its attendant regimentation and reduced opportunities for individual expression, works a hardship on the feminine members of the service, perhaps in a greater degree than on their brothers-in-arms. On the other hand, it is to the credit of the opposite sex that so many were able to make the transition to military life during the past war, often with an efficiency and sense of personal satisfaction not previously achieved in civil life. It is felt that psychiatric assistance plays a role in continuing the successful integration of women into the naval service.

Marital and family problems of both officers and men frequently arise wherein services are needed that neither the chaplain nor the legal officer can provide. Medical officers who are trained to appreciate the variations in personality organization, and the psychological needs of the individual, can often assist patients to understand and solve the conflicts which arise in the family circle. In so doing, they are contributing not only to the mental and social health of the community, but to the efficiency

of the naval personnel involved.

It is the writer's opinion that a psychiatrist should be available at all large dispensaries. A relatively large naval community may be served on an out-patient basis by one medical officer so trained. Dr. Morris Levine, in reference (M), discusses some 40 methods of psychotherapy for the mentally or emotionally ill patient. Study reveals that 35 of these techniques are suitable for use on an office or out-patient basis. Dispensary psychiatrists could, and should be, looked upon in a sense as engaged in preventive medicine. They should be seeing patients who are in the incubation stage of emotional illness while tension is the predominant etiologic factor, and before the appearance of such disorders as ulcers, hypertension, asthma, and chronic gastro-intestinal dysfunctions, which would necessitate hospitalization.

Keeping men on the job both prevents lost manpower and lessens the patient load for the hospital staff. We know that wartime experience conclusively showed treatment near the front lines to be more effective than treatment in the rear areas. In like manner it is maintained that treatment while the patient is still on the job is much more effective than after he has been hospitalized. In addition, we can thus avoid the psychic contagion often seen in hospital wards when the medical discharge of one or two patients results in other poorly motivated personnel becoming "survey happy."

Admiral Swanson, our Navy Surgeon General, speaking to the Reserve Naval medical officers at a recent meeting of the American Psychiatric Association, firmly supported these ideas when he said: "Let me say most emphatically that, as I see it, the responsibility of psychiatry in the armed forces is by no means one solely of eliminating the obviously unfit; psychiatry can be of great significance in assisting our training officers to discover the spark of positive motivation in new recruits, and to point the way of fanning this spark into the flame of effective, responsible personnel; and beyond all this, we must explore the possibility of a really preventive psychiatry in our training centers and schools, and in operational and combat units."

Commander Thomas A. Harris called the attention of the American Psychiatric Association to the role of the psychiatrist in the future. He pointed out the devastating psychological effects of atomic warfare on initiative and personal effectiveness through demoralizing hysteria, and expressed a hope psychiatrists could prepare the civilian population to cope with these tendencies.

Aviation activities offer an unusual opportunity for the services of a psychiatrically trained medical officer. Here, in an environment where even the routine daily training activities pose a constant threat to the safety of the individual flyer, tension states of varying degree present an ever-present problem for the Medical Department. It is an impossible goal to expect selection processes to eliminate these hyperreactive individuals, and it is not necessarily a desirable goal. It is felt that any aviation activity of appreciable size should have a psychiatrist who is also a flight surgeon as an important member of the medical staff.

Other places where a psychiatrist can be efficiently and effectively utilized are at the larger naval schools, with task groups, and with fleets.

It is suggested that the assistant staff medical officer of major air commands, both training and operational, should be a medical officer with graduate training in psychiatry. It is perhaps appropriate here to suggest, too, that the addition of a psychiatrist to the teaching staff of the General Line School would be a definite step forward in the general orientation of the younger line officer. This would enhance his understanding of the dynamics of inter-personal relationships, and thus would contribute to his over-all ability as he progressed to command rank.

The type of medical officer best qualified to discharge the duties outlined in this paper is one in the intermediate ranks who has had a good general medical background with graduate training in the field of psychiatry. It is not necessary that the men in these billets be certified by the American Board of Psychiatry, although such added qualification is desirable. Flight surgeons have in general had a better grounding in psychiatry than the general service medical officer, and in many instances would

be qualified to serve in such a billet as outlined, providing at least one, preferably two, additional years of graduate training in psychiatry, either in naval or civilian facilities, was afforded. In order to avoid the assumption of a label as a "specialist" too early in their service careers, these medical officers should stand all regular watches and collateral duties. Care of gynecological, pediatric, urological, E.E.N.T., and general medical cases on watches is considered a necessary part of the professional experience of these medical officers. In this manner they do not sacrifice their all-round medical ability, which has long been a source of personal and professional pride to the career naval medical officer.

At the large stations a psychologist who can serve as an assistant to the psychiatrist is considered an invaluable colleague. This is in line with the experience in the military services during World War I, when they cooperated both in the selection and training of personnel. Furthermore, this follows in part the *team* idea, which proved to be so satisfactory in the hospital care of psychiatric patients during the past war.

Since the cardinal mission of the Medical Department is to maintain the health of the service as well as to promote morale and to plan for increasing efficiency, it is maintained that the assignment of psychiatrists to dispensaries and the other extra-hospital functions is a desirable step forward toward the goal of providing mental hygiene clinics for service personnel. Certainly it must be recognized that the provision of such facilities for service people is a progressive step in the field of preventive medicine and fully as important as is the role of Veterans Administration or community mental hygiene clinics. For, to quote Dr. William A. White, "the production and maintenance of morale is a psychiatric problem that affects the whole nation at arms—the worker and the farmer, the parent and teacher, civilian administrative personnel, the executive department and the entire military and naval establishment. The protection of morale, of concentrated motivation, and of solidarity, are much more economical than are remedial efforts after disastrous failures."

SAMPLE EXAMINATIONS FOR THE STUDENT OFFICER'S PRACTICE

FIRST NEUROPSYCHIATRIC EXAMINATION

Answer any six. Time 50 minutes.

No. Value QUESTION

Score: Question value indicated.

1. (15) Discuss the reasons a flight surgeon should know something of neuropsychiatry.
2. (15) Discuss the body-mind reciprocal relationship.
3. (15) Discuss the influence of environment on personality.
4. (15) Outline the psychosexual development of the individual.
5. (10) Identify and discuss briefly your ideas of Id, Ego, and Super-Ego and their relationships.
6. (10) Discuss the psychoanalytic concept of "fixation" and its possible influence on personality in later life.
7. (10) Distinguish between conditioning and precipitating factors in the etiology of emotional illness.
8. (10) List several sources of internal stress in military environment. Which two or three do you consider the more important?
9. (10) Define and illustrate:
   a. Complex.
   b. Rationalization.
   c. Projection.
   d. Delusion.
   e. Identification.

Take any six questions.

1. (15) Discuss briefly the development of the personality as seen by the psychobiological adherents.
2. (10) Mention five important points in history-taking and six headings for the direct mental examination of a psychiatric patient.
3. (10) Indicate the three major headings under which psychoses may be considered and illustrate with two examples of each group.
4. (10) Discuss the constitutional psychopathic inferior.

5. (10) List several types of possible traumatic reactions and discuss the importance of an appreciation of these reactions in *Aviation Medicine.*
6. (15) Define a psychoneurosis. List three types and illustrate the basic symptomatology in each.
7. (15) What is meant by psychosomatic medicine? Illustrate by a brief hypothetical case.
8. (15) Identify a chronic alcoholic, give the etiology and your approach to treatment.

To answer the following 20 questions make a + (true) or a — (false) for each question in the left-hand margin opposite each number as appropriate:

1. The chronic alcoholic is a neurotic drinker.
2. A girl usually undergoes one more stage than the male in the solution of the Oedipus Complex.
3. Conversion hysteria is the only neurosis which does not show some impairment of sexual function.
4. The personality type usually seen in the obsessive-compulsive neurosis is serious, and intolerant of human foibles.
5. *Emotional Problems of Living* was written by Strecker and Appel.
6. Progressive deterioration is an incidental finding in organic psychoses.
7. Adolph Meyer introduced the concept of psychobiology.
8. In infancy instinctual tensions are mostly from internal physiologic needs.
9. Instincts do not follow the pleasure-pain principle.
10. The superego shows no expression of the influence of the parents.
11. Many principles of psychotherapy are contrary to religious teachings.
12. There are psychotherapeutic procedures which are not time-consuming.
13. Cases of accidental homosexuality will rarely be seen by the naval medical officer.
14. Secondary gains are a large factor in traumatic neuroses.
15. The rule that a person who is afraid of insanity does not become insane is true.
16. The person who claims he will commit suicide is more likely to do so than the depressed patient.
17. Treatment of obsessive-compulsive disease is usually unsuccessful.
18. Action is a good outlet for anxiety.
19. All unusual or bizarre thoughts indicate psychoses or abnormality.
20. Daydreaming is a dangerous activity.

MULTIPLE CHOICE

1. You are asked by the air group commanding officer to recommend a man to him to fill the following billets. Choose people in column 2 to match the billets in column 1 so that the man best suited by personality gets the proper billet.

_____Air group historian.
_____Engineering officer.
_____Entertainment officer.
_____Air combat intelligence officer.
_____Athletic officer.

A. Extroverted, husky, popular single man.
B. Syntonic, popular, salesman type.
C. Schizoid, erudite, literary college graduate.
D. U. S. Naval Academy graduate, class 1948-B.
E. Older, calm, sincere officer with degree in business administration.
F. High school graduate disinclined to exert self.
G. MIT graduate, with degree in mechanical engineering.
H. Passed-over lieutenant inclined toward irresponsibility.

2. You are at sea beginning a six-months cruise with a newly commissioned air group. Underline the cases you would be able to handle successfully aboard the carrier for at least six weeks:

a. Mild anxiety state precipitated by financial worries.
b. Acute alcoholism.
c. Paranoid state.
d. Personality disorder (immaturity).
e. Catatonic schizophrenia.
f. Petit mal.
g. Old paretic showing some deterioration.
h. Acute transient tension state with headache.

i. Obsessive-compulsive state (kleptomania).
j. Meningioma with acute symptoms.

3. The universal goal of people is: (Underline.)
   a. Financial success.
   b. A home, wife, and family.
   c. Peace of mind.
   d. Promotion.
4. The dissimilar term in the following is: (Underline.)
   a. Projection.
   b. Disintgeration.
   c. Introjection.
   d. Rationalization.
5. A psychiatrically trained medical officer can be of most service: (Underline.)
   a. Aboard ship with an operational squadron.
   b. At the college where midshipmen get their two years' study.
   c. On major commanders' staffs'.
   d. At the primary training level.
6. Underline the word which is dissimilar:
   a. Libido.
   b. Anal sadistic.
   c. Latent content.
   d. Anergasia.
7. Reassurance, desensitization, pentothal interview, education, and routinizing are all forms of:
   a. Hospitalization.
   b. Psychotherapy.
   c. Analysis.
   d. Psychobiology.
8. Elation, flight of ideas, circumstantiality, and increased psychomotor activity are seen in:
   a. Hypomania.
   b. Frontal lobe tumor.
   c. Arteriolosclerosis cerebri.
   d. Psychomotor equivalent.
9. Underline the dissimilar word:
   a. Pinel.
   b. Jones.
   c. Charcot.
   d. Freud.
   e. Strecker.
   f. Weir Mitchell.
   g. Bleuler.
   h. Breuer.
   i. Herschkowitz.

COMPLETION

1. Burlingame likens a balanced personality to a four-legged chair and maintains that any *leg* out of proportion causes an unbalanced personality. The legs in such example are:
   1. ____________
   2. ____________
   3. ____________
   4. ____________
2. The personality consists of three portions, according to the psychoanalytical school. These are:
   1. ____________
   2. ____________
   3. ____________
3. One of the great foundation stones utilized for the structure of psychoanalysis is the concept that mental processes actively function on what may be thought of as different strata or levels. These are called:
   1. ____________
   2. ____________
   3. ____________
4. Three essential constituents of peace of mind are:
   1. ____________
   2. ____________
   3. ____________
5. Three fundamental urges or instincts are those of:
   1. ____________
   2. ____________
   3. ____________
6. A group of related ideas bound together by____________and striving for action is collectively called a________.
7. Disguises employed by repressed ideas and desires seeking reentry to consciousness are known collectively as____________. Examples are:
   1. ____________
   2. ____________
   3. ____________
8. Kretschmer classified people into four anthropological groups:
   1. ____________
   2. ____________
   3. ____________
   4. ____________

While Sheldon in a somewhat similar manner classified people into three classes by physique:

1.____________________
2.____________________
3.____________________

and matched these by three temperament types:

1.____________________
2.____________________
3.____________________

9. According to Menninger some of the type personalities prone to have unusual difficulties under adaptational strain are:

1.____________________
2.____________________
3.____________________
4.____________________

10 Some of the more important symptoms of anxiety hysteria are:

1.____________________
2.____________________
3.____________________

11. Some of the outstanding diagnostic criteria regarding the psychopathic personality are:

1.____________________
2.____________________
3.____________________
4.____________________

12 Manic-depressive reaction, involutional melancholia, and psychotic depressive reaction are all classed as________________disorders.

13. Some of the major psychoneurotic disorders, according to the new nomenclature, are:

1.________________reaction
2.________________reaction
3.________________reaction
4.________________reaction

14. Illustrative somatization reactions are:

1.________________reaction
2.________________reaction
3.________________reaction

15. One of the most severe mental diseases without known organic patholgy is________.

DISCUSSION

1. A pilot in your air group begins to louse-up his landings. You note he is becoming irritable and moderately aloof. You try to be friendly and offer to help if you can. He tells you to "mind your own G - - D - - - business, Doc; I'm all right."

Briefly discuss what action on your part might be appropriate.

SECOND NEUROPSYCHIATRIC EXAMINATION

1. It is obligatory that any doctor practicing medicine, either in the civilian or military setting, must have:

a. Maximum psychiatric information.
b. No psychiatric information.
c. A minimum of psychiatric information.

2. The brain was declared to be the organ of the mind by:

a. Hippocrates.
b. Pythagoras.
c. Galen.

3. Chains were removed from mentally ill patients, and they were considered as patients rather than criminals, first by:

a. Charcot.
b. Jung.
c. Pinel.

4. In the field of psychiatry, there are numerous sub-specialties. Among these are:

a.____________________
b.____________________
c.____________________
d.____________________
e.____________________

5. In the daily practice of medicine, a large segment of functional sickness is seen. It has been said that such cases make up over______ percent of a doctor's practice.

6. Scientific research has still not isolated the specific etiological factor in such diseases as ____________ and ____________.

7. Neguchi and Moore are best remembered for having demonstrated the____________ in the ____________ of ____________.

8. In regard to psychiatric illnesses, some of the more important predisposing causes are:

a.____________________
b.____________________
c.____________________
d.____________________
e.____________________
f.____________________

9. Exciting causes of emotional disorders may be either preponderantly____________ or____________.

10. ________________ activate and energize behavior.

11. Strecker classifies mental diseases as being in one of the following three groups:

a.________________________________

b.________________________________

c.________________________________

Under a, some examples are:

____

____

____

Under b, two examples are:

____

____

Under c, two examples are:

____

____

12. Behavior in schizophrenia is best described as being ____________ or ____________. The schizophrenic's emotional life is strikingly ________________. Schizophrenia is usually classified in the following four sub-groups:

____

____

____

____

13. Pyknics tend to be________________________ or predominantly outgoing people, while the leptic type tends to be________________________or predominantly ingrowing in personality.

14. A psychiatric examination includes not only a physical examination but a____________ examination. Under the latter, the following headings should be considered:

a.________________________________

b.________________________________

c.________________________________

d.________________________________

e.________________________________

f.________________________________

15. Flight of ideas is a symptom most often seen in________________disease.

16. Insight is the capacity of the patient to look at himself and his symptoms and__________ that he is mentally sick.

17. In organic psychoses, there is progressive deterioration of:

a.________________________________

b.________________________________

c.________________________________

18. Paroxysmal cerebral dysrhythmia is also known as________________. Manifestations of this illness are considered under the headings of ________________, ________________ and

19. ________________________is a progressive

19. ________________________is a progressive degenerative disease of middle life entailing severe dementia and in which inheritance plays a significant role.

20. Prominent disturbances of sensorium and consciousness varying in degree from mere clouding to a full-fledged delirium with marked motor activity, complete disorientation and a vivid illusory and hallucinatory content, are symptomatic of________________psychoses.

21. A *Philadelphia Cocktail*, consisting of the intravenous administration of 100 cc. of 50 glucose, 100 mgm. of thiamin chloride and 30 units of insulin, is used in the treatment of ________________ ________________, which is a delirium encountered in patients who use ________________to excess.

22. In bromide intoxication, a blood bromide concentration above__________mgm. is dangerously high. The important aspect of therapy is the administration of________________________ ________________________.

23. Shellshock is actually________________ ________________, and the conflict is between the instincts of________________ ________________ and the expectations and demands of__________ ________________________.

24. Regression, rationalization, repression, projection, and introjection are examples of ________________ ________________.

25. A spike and dome EEG tracing is characteristic of________________ ________________.

26. In the depressed phase of manic depressive psychosis, the thoughts become sluggish and are expressed with the greatest difficulty. This is known as________________. In involutional melancholia, however, there is marked useless activity, and the depression is said to be an________________one.

27. Hallucinations may occur in every psychosis except________________________.

28. Delusions which are self-accusatory or in which the patient feels he has committed an unpardonable sin are most often seen in ________________disease and in________________ ________________________.

29. A thought which dominates the mind and personality of the patient and which cannot be put out of consciousness is known as an ______________________.

30. A person who cannot correctly relate himself as regards person, time, and place is said to be ______________________.

31. An important factor in aviation medicine, which may be responsible for marked behavior deviations, is __________ __________.

32. An acute infectious disease which likewise may cause marked behavior problems is ______________ ______________.

33. The illness in which there is memory loss but fairly good appreciation of immediate impressions, and in which there is confabulation with falsification of memory, is known as ______________ ______________.

34. A drug which is usually smoked in cigarettes and which may produce serious mental disturbances, chiefly a manic-like delirium, is ______________.

35. ______________, more often unconscious than conscious, is a vital and dynamic conception and considered basic as to psychopathologic mechanisms.

36. The neurosis in which fatigue is so marked, and in which the patient may become hypchondriacal, even though she is organically sound, is known as ______________________.

37. An effective but pathologic device which enables the neurotic patient to escape the disapproval of his own self-ideal and the condemnation of the herd by so camouflaging unworthy motivations that even to that sternest critic, his own ego, they appear satisfactory, even praiseworthy, is ______________________.

38. Possibly the most serious disease menace of modern civilization is ______________________.

39. The disease in which delusions of persecution are prominent, and contact with reality is largely lost, and in which latent homosexuality plays a definite etiologic role, is known as ______________ ______________.

40. The type of schizophrenia which offers the poorest prognosis is ______________________.

41. ______________ ______________ is one of the main clinical territories of the special fears or phobias. It is important to remember these phobias represent a ______________ for deeply-hidden psychopathologic material, and that the phobias exist in order to keep out of consciousness submerged complexes which the personality of the patient cannot face.

42. ______________thinking may remain ruminative and not eventuate in compulsive behavior.

43. One of the most essential factors in treatment of functional emotional conditions is to keep the patient______________.

44. A life-long history of emotional instability, occupational inadequacy, impulsive conduct, absence of ethical and moral considerations, disregard of truthfulness, decency and social responsiveness, is justification for a diagnosis of______________ ______________.

45. The most important place for the psychiatrist relative to his service in a military organization is at the early stages of__________.

46. Whereas in World War I the common neurosis was a relatively simple, somewhat naive conversion hysteria, in World War II the preponderant psychoneuroses were______________ ______________.

47. In his personality traits, the alcoholic is more apt to be preponderantly an__________ than an______________.

48. The person who cannot face reality without alcohol, and yet whose adequate adjustment to reality is impossible so long as he uses alcohol, is known as a______________ ______________.

49. A return to a former somewhat primitive and rather childish type of behavior which has as its object the domination by the individual of some life situations, is known as ______________________.

50. Flight into reality with destructability and accentuated psychomoter activity is characteristic of______________ ______________ ______________________.

51. A disorder characterized by transient delusions of persecution, without the bizarre fragmentation and deterioration of the schizophrenic, is called______________ ______________.

52. A severe depression with self-blame and suicidal trends, but without the constitutional or recurrent tendency of true manic depressive disease, and in which the mind of the patient there is clear cause and effect connection between the environmental vicissitudes and the depression suffered, is known as a______________

SEMINARS

Seminar No. 1:

Navy Film—*The Neuropsychiatric Patient.* Illustrating the proper approach to the care of a mental case.

Seminar No. 2:

Psychiatric experiences in World War II. Presentation of articles and discussion.

Reference:

(Z)—complete article.

Seminar No. 3:

Combat fatigue. Discussion of appropriate method of handling.

Reference:

(AA)—Complete article.

Seminar No. 4:

The technique of the neuropsychiatric examination.

Reference:

(T)—Pages 39-62.

Seminar No. 5:

Schizophrenia:

1. Schizophrenic Dynamisms.
2. The pattern of schizophrenia.
3. Varieties of schizophrenia.
4. Case presentation.

References:

(K)—pages 67-80.
(Q)—section II.
(X)—pages 407-450.

Seminar No. 6:

Manic depressive disease:

1. Etiology, psychopathology, and symptomatology.
2. Causes and symptoms.
3. Manic states.
4. Depressed and mixed phases.
5. Depression.
6. Physical symptoms, course, prognosis, and treatment.

References:

(BB)—Pages 130-136; 137-157; 166-175.
(D)—Pages 396-426.

Seminar No. 7:

Navy film—*Combat Fatigue, Psychosomatic Disorders.* A dramatic presentation of patients suffering these disorders.

Seminar No. 8:

Written examination on *Fundamentals of Psychiatry* by Dr. Strecker.

Seminar No. 9:

Head injuries and cranial trauma:

1. Concussion and contusion.
2. Intra-cranial hemorrhage.
3. Treatment.
4. Complications.

Seminar No. 10:

Alcoholism. Speaker from *Alcoholics Anonymous* with group discussion.

References:

(DD)—complete.
(EE)—complete.
(X)—pages 236-255.

References:

(D)—pages 202-209; 272-288; 290-300; 323-330.
(X)—pages 182-195.
(FF)—page 298.

Seminar No. 11:

Organic psychoses and epilepsy:

1. Epilepsy; phychoses with epilepsy.
2. Psychoses with cerebral arteriosclerosis and circulatory disturbance. Senile psychoses.
3. Psychoses with epidemic encephalitis; psychoses with brain tumor; phychoses with organic change of central nervous system.

References:

(D)—pages 61; 511, 512.
(J)—pages 286-310.
(M)—complete.
(R)—pages 554-589.
(T)—pages 176-187.
(Y)—pages 323-331; 368-406.

Seminar No. 12:

Psychotherapy

Reports on current practices in the use of electroshock, insulin shock, electronarcosis, hypnosis, pentothal interview, etc.

Seminar No. 13:

National Film Board of Canada films: The Feeling of Rejection. The Feeling of Hostility.

Seminar No. 14:

Neuropsychiatric evaluation of prisoners and failing flight students.

The role of the flight surgeon in evaluating prisoners for courts and retraining commands, and the flight surgeon's study of the student aviator having ground or air difficulties; discussion by the legal officer of the types of naval courts and the role expected of medical officers.

References:

(GG)—complete.

Seminar No. 15:

U. S. Army film, *Shades of Grey.*

Seminar No. 16:

Test of diagnostic ability with pseudo-dramatization of cases by instructor.

Seminar No. 17:

Journal reports.

References:

As listed under *Journal References.*

Seminar No. 18:

Case presentation of homosexuality:

References:

(HH)—pages 610-666.
(R)—selected references.
(H)—page 400, plus other references.
(A)—pages 258-295.
(J)—pages 276-285.
(G)—pages 50; 143; 148; 226; 288.

Seminar No. 19:

Original cases for diagnosis.

Each student is requested to prepare three hypothetical psychiatric cases to be presented for diagnosis. Each abstract should be 300 to 600 words in length, present sufficient details for diagnosis, but not make the case too obvious. The goal is the preparation of

succinct summaries, and the ability to make rapid diagnosis on the possession of critical factors.

REFERENCES—NEUROPSYCHIATRY

A. *The Human Mind,* Karl A. Menninger, Alfred A. Knopf, New York, 1946.

B. *Peace of Mind,* J. L. Liebman, Simon and Schuster, New York.

C. *The Mask of Sanity,* Hervey Cleckley, M. D., The C. V. Mosby Company, St. Louis, Missouri, 1941.

D. *Modern Clinical Psychiatry,* Arthur P. Noyes, M. D., W. B. Saunders Co., Philadelphia, 1940.

E. *Men Under Stress,* Roy R. Grinker, Lt. Col., MC, Army Air Forces, and John P. Spiegel, Major, MC, Army Air Forces, Blakiston, Philadelphia, 1945.

F. *Psychosomatic Medicine,* Edward Weiss, M. D., and O. Spurgeon English, M. D., W. B. Saunders Co., Philadelphia, 1943.

G. *Freud's Contribution to Psychiatry,* A. A. Brill, M. D., W. W. Norton Co., Inc., New York, 1944.

H. *The Structure and Meaning of Psychoanalysis,* William Healy, M. D., Augusta F. Bronner, M. D., Anna Mae Bowers, A. B., Alfred A. Knopf, New York, 1946.

I. *Lectures on Psychoanalytic Psychiatry,* A. A. Brill, M. D., Alfred A. Knopf, New York, 1946.

J. *Common Neuroses of Children and Adults,* O. Spurgeon English, M. D., and Gerald H. J. Pearson, M. D., W. W. Norton and Co., Inc., New York, 1937.

K. *Principles of Dynamic Psychiatry,* Jules H. Masserman, M. D., W. B. Saunders Co., Philadelphia, 1946.

L. *Psychoanalytic Therapy,* Franz Alexander, M. D., Thomas Morton French, M. D., The Ronald Press Co., New York, 1946.

M. *Psychotherapy in Medical Practice,* Maurice Levine, M. D. The MacMillan Co., New York, 1946.

N. *A History of Medical Psychology,* Gregory Zilboorg, M. D., W. W. Norton, Inc., New York, 1941.

O. *The Neurotic Personality of Our Time,* Dr. Karen Horney, W. W. Norton, Inc., New York, 1937.

P. *Emotional Problems of Living,* Pearson and English, W. W. Norton, 1945.

Q. *The Biology of Schizophrenia,* R. G. Hoskins, M. D., W. W. Norton, 1946.

R. *Psychoanalytic Theory of Neurosis,* Otto Fenichel, M. D., W. W. Norton, 1945.

S. *Outline of Neuropsychiatry in Aviation Medicine,* Army Air Forces, School of Aviation Medicine, Randolph Field, Texas.

T. *Fundamentals of Psychiatry,* Edward A. Strecker, M. D., J. B. Lippincott Co., Philadelphia, 1943.

U. *Outline of Neuropsychiatry in Aviation Medicine,* War Department Technical Manual, TM 8-325.

V. *A Textbook of Clinical Neurology,* Israel S. Wechsler, M. D., W. B. Saunders Co., Philadelphia, 1943.

W. *Orientation to Psychosomatics,* Major Henry A. Davidson, Medical Reserve, U. S. Army.

X. *Practical Clinical Psychiatry,* E. A. Strecker, M. D., and Franklin G. Ebaugh, M. D., The Blakiston Co., Philadelphia, 1940.

Y. *Outline For Neuropsychiatric Examination in Aviation Medicine,* Captain E. L. Caveny, MC, USN, Chief of Neuropsychiatry, U. S. Naval Hospital Philadelphia, Pennsylvania.

Z. *Psychiatric Experiences in World War II,* American Journal of Psychiatry, March 1947.

AA. *Combat Fatigue,* BuMed News Letter 18 August 1944.

BB. *A Textbook of Psychiatry,* D. K. Henderson and R. D. Gillespie, Oxford University Press, New York, New York, 1943.

CC. *Injuries of Skull, Brain, and Spinal Cord,* Samuel Brock, Williams and Wilkins, Baltimore, 1940.

DD. *Alcoholics anonymous,* Works Publishing, Inc., New York, 1947.

EE. *Alcohol—One Man's Meat,* Edward A. Strecker and Francis T. Chambers, Jr., The Macmillan Company, New York City, New York, 1945.

FF. Gallinek in Journal of Mental and Nervous Diseases, Vol. 108, No. 4, October 1948.

GG. BuPers 1tr Pers-5212-AJA, P13-10, dated 15 December 1944.

HH. *Sexual Behavior in the Human Male,* Kinsey, Pomeroy, and Martin, W. B. Saunders Co., Philadelphia, 1948.

JOURNAL REFERENCES

" 'Experimental Neurosis' resulting from Semi-Starvation in Man"—Schiele, in *Psychosomatic Medicine,* May-June 1948.

"The Role of Motivation"—Hawley, in *American Journal of Psychiatry,* June 1948.

"Patient-Physician Relationship in Psychotherapy"—Coleman, in *American Journal of Psychiatry,* June 1948.

"Psychiatric Problems of Adolescence"—Mohr, in *Journal of the American Medical Association,* 28 August 1948.

"The Use of Ergotamine Compounds in the Treatment of Acute Simple Anxiety States"—Kelley, in *American Journal of Psychiatry,* April 1948.

"Psychoses Occurring among Psychopathic Personalities"—Ripley, in *American Journal of Psychiatry,* July, 1948.

"The Problem Soldier and the Army"—Caldwell, in *American Journal of Psychiatry,* July 1948.

"The Infantile Personality"—Ruesch, in *Phychosomatic Medicine,* May-June 1948.

"Personality Types in Soldiers with Chronic Non-Ulcer Dyspepsia"—Rosen et al, in *Psychosomatic Medicine,* May-June 1948.

"The Effort Syndrome and Low Back Pain"—Moloney, in *Journal of Nervous and Mental Diseases,* July 1948.

"The Flight Surgeon—His Role in Student Pilot Training"—Cummings, in *The Military Surgeon,* May 1947.

"Treatment of Hysterical Amnesia by Pharmacology" —Myerson, in *New England Journal of Medicine*, 29 May 1947.

"Emotional Problems of a Flight Surgeon with an Air Group"—Requarth, in *Naval Medical Bulletin*, March-April 1947.

"Camptocormia, or the Functional Bent Back"—*Psychosomatic Medicine*, May-June 1947.

"Psychogenesis and Psychotherapy in Ulcerative Colitis"—*Psychosomatic Medicine*, May-June 1947.

"Psychosomatic Medicine—Somatization Reactions" —*Psychosomatic Medicine*, March-April 1947.

"Brief Psychotherapy in Psychosomatic Problems"—*Psychosomatic Medicine*, March-April 1947.

"Ocular Manifestations of Psychosomatic Disorders" —Harrington, in *Journal of the American Medical Association*, 133-669.

"Central Angiospastic Retinopathy"—Zeligs, in *Psychosomatic Medicine*, March-April 1947.

"Emotional Factors in Urticaria"—Kaywin, in *Psychosomatic Medicine*, March-April 1947.

"The Psychological Component in a Case of Herpes Simplex"—Schroeder, in *Psychosomatic Medicine*, January-February 1947.

"Psychosomatic Aspects of Dermographia and Pruritus"—Dengrove, in *Psychosomatic Medicine*, January-February 1947.

"Herpes Simplex and Second Degree Burn Induced under Hypnosis"—*American Journal of Psychiatry*, May 1947.

"Psychological Factors in Men with Peptic Ulcers"—*American Journal of Psychiatry*, March 1947.

"Neuropsychiatric Manifestations during the Course of Malaria"—Brookes, in *Archives of Neurology and Psychiatry*, July 1947.

CHAPTER 10

AVIATION PHYSICAL STANDARDS AND THE GENERAL PHYSICAL EXAMINATION

EDITOR'S NOTE.—Consult a currently corrected copy of the *Manual* of the *Medical Department*, U. S. Navy, for the aviation physical standards, because changes are made from time to time.

The following general provisions and standards for physical examinations are taken from the *Manual of the Medical Department*, section XXV, aviation:

21137.—*Object.*—The object of the aviation examination and the instructions incident thereto is to select for flying duty only such officers and enlisted men as are physically and mentally qualified for such duty, and to remove from flying duty those who may become temporarily or permanently unfitted for such duty because of physical or mental defects. Physical qualifications shall in general conform to the standards prescribed in previous sections. In addition, properly authorized applicants for duty involving actual control of aircraft shall qualify on psychological tests described in technical memoranda and directives issued by the Bureau.

21138. CLASSIFICATION OF PERSONNEL REQUIRING THE EXAMINATION

21138.1.—Aviation personnel are divided in two classes:

Class 1.—Aviation personnel engaged in actual control of aircraft, which includes naval aviators, student naval aviators, naval aviation pilots, student naval aviation pilots, naval aviation cadets, lighter-than-air-pilots, student lighter-than-air-pilots, and student flight surgeons.

Class 2.—Aviation personnel not engaged in the actual control of aircraft, which includes naval aviation observers, naval aviation navigators, naval flight surgeons, combat aircrewmen, and other persons ordered to duty involving flying.

21138.2—Class 1 is considered regular flying personnel and shall take the complete physical examination for flying. For this purpose, Class 1 is further divided into flying service groups, based on the age of the aviator and other conditions, for which special physical requirements are prescribed in paragraph 21141.

21138.3—Class 2 shall meet the standard physical requirements for the general service with such additional requirements as are prescribed in paragraph 21141.2.

21138.4—When submitting a Standard Form 88 (Report of Physical Examination for Flying), flight surgeons and aviation medical examiners shall state whether any defect noted is considered disqualifying.

21138.5—The examination for flying shall be limited to members of the aeronautical organization and properly authorized applicants for this service. Applicants shall be given a preliminary physical examination by the local medical and dental officers to eliminate those who obviously cannot meet the physical requirements for aviation.

21139 RESTRICTIONS UNTIL PHYSICALLY QUALIFIED

21139.1—No person shall be assigned to duty involving actual flying until he has successfully passed the physical examination for flying prescribed herein, and, except as authorized in paragraph 21139.4, until official notification has been received from the Bureau that such person is physically qualified for that duty.

21139.2—All applicants, commissioned or enlisted, including those in the naval aviation

college program for aviation training shall successfully pass the physical examination for flying. The examination must not antedate the application by more than six months. When an applicant for aviation training is not in the vicinity of one of the ships or stations where the physical examination for flying can be made, he shall be examined in accordance with the instructions governing the examination of candidates for commission and shall be expected to meet the standards set forth as acceptable for a commissioned officer. Before being assigned to duty involving flying under training as a pilot, he shall be given the complete physical examination for flying at the station to which he may be attached for training.

21139.3—Pilots of the Naval Reserve who apply for permission to pilot naval aircraft shall be subjected to the examination prescribed herein unless they present satisfactory evidence that they have passed such an examination within six months of the dates on which flight is desired.

21139.4—Pending receipt of the approved copy of the record of physical examination (par. 21146), or certificate from the Bureau that the record of the physical examination has been approved, personnel may be considered physically qualified if an authorized medical examiner (par. 21145) certifies that the applicant has no physical or mental defect that would disqualify him for flying.

21140. POLICIES ON SERVICE GROUPS FOR PILOTS OF NAVAL AIRCRAFT

21140.1—The following policies shall, in general, be followed in the assignment of pilots of naval aircraft to flight duties:

Service group I: Pilots under 40 years of age. Unlimited.

Service group II: Pilots of 40 to 50 years of age, or younger pilots who, for other reasons, are not qualified for unrestricted flying in service group I, but who are so qualified for unrestricted flying in service group II, shall not be assigned to fighter, bomber, or torpedo squadrons.

Service group III: Pilots over 50 years of age shall normally be expected to perform flights in executive or broad command status. Solo flying shall be performed in such basic types of naval aircraft as may be prescribed by the Deputy Chief of Naval Operations for Air, as believed commensurate with their physical and service qualifications.

Pilots of younger age groups who for physical or other reasons are not qualified for unrestricted flying in their service group, but who are physically and otherwise qualified for flying in service group III, may be so employed when sufficiently justified by other considerations. Normally the assignment of pilots below the rank of captain to service group III shall be restricted, and shall be limited to individuals recovering from illness or injury or to individuals not physically qualified for other service groups whose flying experience and the needs of the service sufficiently justify their employment in a limited pilot status.

21140.2—The physical requirements employed in determining the above service groups are provided in paragraph 21141.

21140.3—Should any pilot fail to meet the physical requirements prescribed for unrestricted flying in his service group, such failure shall be set forth in the Standard Form 88 (Report of Physical Examination for Flying), and the report forwarded to the Bureau. The Bureau will submit its recommendation to the Bureau of Naval Personnel via the Deputy Chief of Naval Operations (Air), and the pilot shall be disposed of as follows:

1. Permitted to continue unrestricted flight status in his Service Group subject to waiver of defects by the Bureau of Naval Personnel.
2. Restricted to flight duties of the next service group, that is, from I to II, or from II to III.
3. Restricted to flight duties of lessened tempo commensurate with present temporary physical condition (pilots recuperating from injuries or illness).
4. Restricted to flight duties of service group III, requiring the presence of a copilot qualified in service group I or II.
5. Dropped from flight status.

21141. PHYSICAL REQUIREMENTS FOR AVIATION PERSONNEL

21141.1—*Class I.*—Aviation personnel engaged in the actual control of aircraft.—(a)

Service group I (pilots under 40 years of age, unrestricted flying). The physical requirements for these personnel shall be those set forth in paragraphs 21149 through 21165 below.

Service group II (pilots 40 to 50 years of age, or younger pilots who for other reasons are not qualified for unrestricted flying in service group I but who are qualified for unrestricted flying in service group II, not to include fighter, bomber, or torpedo squadrons). Physical requirements for unrestricted flying in service group II shall be the same as those prescribed for service group I, with the following exceptions:

1. Visual acuity shall be not less than 10/20 for each eye unaided by glasses, provided that when visual acuity is less than 13/20 for either eye, it shall be corrected by lenses to 20/20 and the correction shall be worn while flying.
2. Variation in depth perception shall not exceed 35 mm. with the aid of glasses.
3. Accommodation below the requirements for age is permissible, provided that accommodation for each eye shall be not less than 3 D without correction. Whenever accommodation is less than 3 D, it shall be corrected to a minimum of at least 3 D by lenses, which correction shall be placed in the lower section of lens only (bifocal or lower half of lens) and be available for use at all times when flying.
4. Moderate defects of hearing may be permitted, but shall not exceed the minimum of 7/5 whispered voice, binaural.

Service group III (pilots over 50 years of age, who will normally be expected to perform flights in executive or broad command status). Physical requirements for unrestricted flying within service group III shall be the same as for service group I, with the following exceptions:

1. Visual acuity shall be not less than 8/20 for each eye unaided by glasses, provided that when visual acuity is less than 13/20 for either eye, it shall be corrected to 20/20 by lenses and the correction worn while flying.
2. Variation in depth perception shall not exceed 35 mm. with the aid of glasses.
3. There shall be no muscle imbalance (phoria) of sufficient degree to result in diplopia within 50 cm. of the central position of the tangent curtain.
4. Accommodation below the requirements for age is permissible, provided there shall be not less than 3 diopters of accommodation for each eye with the aid of glasses and the correction shall be placed in the lower section of lens only (bifocal or lower half of lens) and be available for immediate use at all times when flying.
5. The diastolic blood pressure shall not regularly exceed 100 mm. Hg. The systolic blood pressure shall not regularly exceed 165 mm. Hg.

21141.2—*Class 2.*—Aviation personnel not engaged in actual control of aircraft: (a) *Naval aviation observers.*—Candidates shall normally be expected to meet the standard physical requirements prescribed for the general service with the following additional requirements as prescribed for naval aviators; namely, accommodation of the eyes, circulatory efficiency, and the neuropsychiatric examination. Reports of examinations shall be made on Standard Form 88, as provided in paragraph 21146. In each case that a Standard Form 88 is forwarded to the Bureau appropriate entries shall be made on the NavMed-H-9 (Aviation Medical Abstract) of the individual's health record.

Naval aviation observers (navigation or tactical).—Candidates shall be physically qualified and temperamentally adapted for duty involving flying in accordance with existing standards for candidates for flight training leading to the designation of naval aviator or naval aviation pilot, except that the ACT, MCT, and BI tests are not applicable, and shall not be administered. Reports of examination shall be made on Standard Form 88 as provided in paragraph 21146. In each case that a Standard Form 88 is forwarded to the Bureau appropriate entries shall be made on the individual NavMed-H-9 (Aviation Medical Abstract) of the individual's Health Record.

Naval aviation observers (radar).—No specific physical standards beyond those for the general service shall be required. Candidates shall be examined physically to determine their fitness to engage in aerial flights, with the examination relating primarily to the circulatory system, neuropsychiatric stability, and patency of the eustachian tubes. The purpose of such

an examination is to eliminate those individuals with physical defects likely to be aggravated by duty involving flying, or to constitute a hazard when performing such duty. The result of the examination shall be entered on the NavMed-H-9 of the individual's health record, and his commanding officer shall be notified as to his physical qualifications. No report of these examinations shall be made to the Bureau.

Naval flight surgeons and aviation medical examiners.—When ordered to duty involving flying (not in control of aircraft), naval flight surgeons and aviation medical examiners shall meet the physical requirements prescribed for naval aviation observers. Reports of examination will normally not be made to the Bureau. In the case of physical disqualification, however, the report of examination shall be regularly prepared on Standard Form 88 and forwarded to the Bureau. When a Standard Form 88 is forwarded to the Bureau appropriate entries shall be made on the NavMed-H-9 (Aviation Medical Abstract) of the individual's Health Record.

Student naval flight surgeons.—Physical requirements for student naval flight surgeons are those prescribed for qualified naval flight surgeons; provided that for the purpose of flight indoctrinal training, in order to be physically qualified to solo elementary type aircraft, vision shall be not less than 15/20 in each eye, unaided by glasses, and depth perception shall not exceed 30 mm. Failure to meet the special requirements of the eyes shall serve to disqualify only for solo flying, but shall not disqualify for other indoctrinal training involving flying, leading to the designation of flight surgeon. Reports of examination will normally not be made to the Bureau. In the case of physical disqualification, however, the report of examination shall be regularly prepared on Standard Form 88 and forwarded to the Bureau. When a Standard Form 88 is forwarded to the Bureau appropriate entries shall be made on the NavMed-H-9 (Aviation Medical Abstract) of the individual's Health Record.

Combat aircrew personnel.—The physical requirements for combat aircrew personnel are in general the same as those prescribed for the general service with the following additional special requirements:

Height.—Maximum height shall not exceed 72 inches (waived in the case of lighter-than-air aircraft machine gunners (Art. 5313(7), Bureau of Naval Personnel *Manual*).

Weight.—Maximum weight shall not exceed 185 pounds (waived in the case of lighter-than-air aircraft machine gunners (Art. 5313 (7), Bureau of Naval Personnel (*Manual*).

Heart and lungs.—A normally functioning cardiorespiratory system in which the blood pressure does not persistently exceed 150 mm. Hg., systolic or 90 diastolic, is a requirement. The Schneider index test shall be conducted only in special cases when so indicated. It alone shall not be cause for rejection.

Eyes.—No abnormality shall be allowed which will interfere with the wearing of goggles or the use of the eyes while in flight. Vision shall be not less than 20/20 in each eye, unaided by glasses. Color vision shall be as prescribed for the general service. Accommodation shall be not less than 3 diopters in each eye, unaided by glasses, as determined by use of the Prince rule or the Jaeger test type.

Nose and ears.—Defects of hearing are allowable, provided such defects are not of sufficient degree as to interfere with radio perception. The eustachian tubes shall be patent. There shall be no evidence of manifest or latent disease of the middle ear or of the accessory sinuses of the face and head. Nasal obstruction shall not exceed 50 percent of total ventilation on either side; a distinction shall be made as between transitory turgescence and anatomical deformity.

Central nervous system.—Applicants shall be examined to determine their freedom from disease of the central nervous system, or evidence of psychic instability of sufficient nature and degree as to disqualify.

Equilibrium.—Equilibrium shall be normal as determined by the self-balancing test.

Speech.—Applicants shall have clear diction for normal spoken voice, with no impediment of speech which will interfere with radio communication.

Reports of the physical examination of combat aircrewmen shall not be made to the Bureau; entries on the NavMed-H-9 (Aviation Medical

Abstract) of the individual's Health Record will serve for this purpose. Commanding Officers shall be officially informed concerning the result of the examinations.

Other nonflying personnel.—When ordered to duty involving flying, for which specific physical requirements have not been prescribed, personnel shall, prior to engaging in such duties, be examined to determine their physical fitness for aerial flights. The examination shall relate primarily to the circulatory system, equilibrium, neuropsychiatric stability, patency of the eustachian tubes, with such additional consideration as the individual's specific flying duties may indicate. The examination and its evaluation shall be of a practical nature. The result of the examination shall be entered on the Nav-Med-H-9 (Aviation Medical Abstract) of the individual's Health Record and the commanding officer officially notified. Reports of these examinations shall not be submitted to the Bureau.

21142. REEXAMINATION FOR PHYSICAL INCAPACITY

21142.1—A reexamination of any individual shall be made whenever considered necessary by the Bureau, the Deputy Chief of Naval Operations for Air, or by the commanding officer, to determine his physical fitness to continue flying duty or flying training.

21142.2—Upon recommendation by the flight surgeon, the commanding officer may relieve from flying duty, or suspend the flying training of, any individual reported physically incapacitated. When the individual is reported physically fit again by the flight surgeon, the commanding officer may authorize resumption of such duty or training.

21142.3—Aviation personnel of class 1 (par. 21138), upon reporting for duty at a new ship or station, or upon reporting for duty following absence due to serious injury or illness, or upon return to duty from a protracted leave of absence, or when otherwise indicated, shall be given such physical examination as may be required to determine their physical fitness to resume their flying duty.

21142.4—When certified as fit for duty by a board of medical survey, a naval aviator or naval aviation pilot shall be examined by a board of flight surgeons as prescribed in paragraph 3323.

21143.—*Annual physical examination.*—All aviation personnel engaged in duty involving actual control of aircraft (par. 21138.2) shall be required to undergo the complete physical examination for flying. Other aviation personnel (par. 21138.3) on their prescribed annual physical examination shall be required to meet the specific physical standards for their classification. Such examinations shall be recorded on Standard Form 88 in the case of those on duty involving actual control of aircraft. These Standard Form 88's shall not be forwarded unless some disqualifying abnormality exists, but are retained in the activity and the results entered on NavMed-H-8's (Medical History Sheets) of the Health Records. In the case of combat aircrewmen and personnel in class 2 (par. 21138.3) ordered to duty involving flying, but not assigned particular flight duties, the results of their examinations shall be recorded in the Health Records on NavMed-H-9's.

21144.—*Examination, where made.*—Equipment and personnel for conducting the physical examination for flying have been established aboard aircraft carriers and the large aircraft tenders, at fleet air bases, and within certain flag commands to which staff flight surgeons are attached; and at naval air stations, Navy and Marine Corps air bases, Naval Reserve aviation bases, and at other shore activities and commands within the several naval districts to which flight surgeons or qualified aviation medical examiners are attached.

21145.—*Examiners qualified.*—The physical examination for flying shall be made only by medical officers who, after a special course of instruction, are qualified to conduct such an examination. The dental examination shall be conducted by an officer of the Dental Corps, if available. There are two groups of medical officers qualified to conduct the physical examination for flying: flight surgeons, who have qualified by taking the basic course in aviation medicine followed by additional indoctrinal flight training; and aviation medical examiners, who have qualified by taking the basic course in aviation medicine but have not received indoctrinal flight training.

21146. RECORDS

21146.1—A record of the physical examination for aviation duty shall be made on Standard Form 88. Reports on qualified personnel shall be forwarded in accordance with instructions on the form.

21146.2—The following procedure shall be observed in examining and reporting upon individuals found not physically qualified or temperamentally adapted for duty involving flying.

Original examination of applicants for flight training—When, on original examination for flying, an applicant for flight training is found physically or psychologically disqualified for the performance of such duty, the report of examination (Standard Form 88) shall be submitted, via the commanding officer, in accordance with existing instructions. Abnormalities disclosed in the neuropsychiatric examination shall be included in the report of examination.

Examination of designated personnel.—Student naval aviators, aviation cadets undergoing regular flight training, student aviation pilots, qualified naval aviators, qualified naval aviation pilots, and qualified navigators who, on physical examination for flying, are considered not qualified for the performance of their flying duties shall appear before a board of medical examiners, of which at least one member shall be a flight surgeon, for the purpose of establishing the nature of their defects and their qualifications for performance of (1) duty involving flying or (2) general duty not involving flying. In the event the defects disclosed as the result of such examination are considered sufficient to disqualify for the performance of general duty not involving flying, the examinee shall appear before a board of medical survey in accordance with instructions in part III, chapter 3, of the *Manual of the Medical Department.*

Personnel temporarily disqualified.—These provisions are not intended to apply to flying personnel who may be disqualified for the performance of their duties because of disabilities considered as temporary (par. 21142).

Commanding officers shall recommend directly to the Chief of Naval Personnel the disenrollment of any naval aviation college program student who fails to maintain the required physical standards. Such recommendations shall be accompanied by Standard Form 88. Assistance may be requested for the physical examinations from the Commandant of the naval district.

21146.3—Naval aviators, naval aviation pilots, student naval aviators, and aviation cadets, on being surveyed to duty following a serious illness or injury, shall appear before a board of flight surgeons, or flight examiners, to determine their physical and temperamental qualifications for return to flight duty. Standard Form 88 shall accompany the survey to the Bureau (Par. 3323).

21147.—*Transfer of records.*—Whenever an individual is transferred from one ship or station to another, the certified copy of his current Standard Form 88 shall be forwarded to the medical officer of his new ship or station.

21148.—*Inspection of records.*—The physical examination records of aviation personnel in Class 1 (par. 21138.1) shall be inspected by the medical and dental officers annually at the end of January. If a medical or dental record is missing or incomplete in any particular, the medical or dental officers shall so inform the commanding officer, who shall direct the individual to report to the medical or dental officers for the necessary examination to complete his records.

21149. THE EXAMINATION

21149.1—Except as modified by the provisions of this paragraph, the general physical examination and general physical standards shall be the same as those prescribed for the general service.

21149.2—Properly authorized applicants for duty involving actual control of aircraft who fail to attain the qualifying scores on psychological tests as specified in technical memoranda and directives of the Bureau shall be disqualified and shall not proceed to the flight physical examination.

21149.3—A history of any of the following shall be considered as disqualifying: syphilis, repeated attacks of hay fever or asthma, recent attacks of malaria, paroxysmal tachycardia, any organic heart disease, recurrent attacks of any of the rheumatic group, recent renal calcu-

lus, encephalitis lethargica, or any illness accompanied by diplopia and lethargy.

21149.4—*Height and weight.*—(3) The minimum height is 66 inches. The maximum height is 76 inches. No specific minimum weight is established. In general the maximum weight shall be 200 pounds, below the age of 40 years, except that applicants weighing in excess of 200 pounds may be accepted without waiver if such excess weight is due to heavy bone structure and musculature and is not due to obesity. Individuals shall be well proportioned. Marked disproportion in the physical proportions is a cause for rejection.

(b) *Chest.*—Any condition that serves to impair respiratory function may be cause for rejection. The examinee, if an average-sized individual should normally have not less than three inches of chest expansion. A variation of one half inch is allowable if the individual is otherwise acceptable.

(c) *Cardiovascular system.*—Cardiac arrhythmia or heart murmur or other evidence of cardial abnormality shall be the cause of careful study, including recourse to an electrocardiographic examination when indicated. Evidence of heart disease shall be cause for rejection.

Blood pressure and pulse rate.—In considering the blood pressure, the examiner must give due regard to the age of the candidate and to physiological causes such as excitement, recent exercise, and digestion. The condition of the arteries, the tenseness of the pulse, and the degree of accentuation of the aortic second sound must be taken into consideration, as must also the relation between the systolic and diastolic pressures. No examinee shall be rejected as the result of a single reading. When the blood pressure estimation at the first examination is regarded as abnormal, or in case of doubt, the procedure shall be repeated twice daily (in the morning and in the afternoon) for a sufficient number of days to enable the examiner to arrive at a definite conclusion. In conducting the circulatory efficiency test (Schneider index), the examinee shall be afforded every opportunity to relax. Loud noise, conversation, and other disturbing influences which may serve to excite or adversely affect the examinee, are to be avoided. The test should not be taken within two hours after a meal. Smoking, fatigue, and intercurrent infections will affect the score. Before taking the test, the subject reclines in a quiet environment for not less than five minutes, after which the examination proceeds as follows:

METHOD

Heart rate is counted for 20 seconds. When two consecutive counts are the same, the 20-second rate is multiplied by three and recorded.

The systolic pressure is taken by auscultation and recorded. Two or three readings should be taken to be certain.

The subject then rises and stands for two minutes to allow the pulse to assume a uniform rate. When two consecutive 15-second counts are the same, multiply by four and record. This is the normal standing rate.

Standing pulse minus the reclining pulse gives the increase on standing.

The systolic pressure is taken as before and recorded.

Timed by a stop watch, the subject steps upon a chair 18½ inches high, five times in 15 seconds. To make this uniform, the subject should stand with one foot on the chair at the count of one. This foot remains on the chair and is not brought to the floor again until after the count of five. At each count he brings the other foot on the chair and at the word "down" replaces it on the floor. This should be timed accurately so that at the 15-second mark on the stop watch both feet are on the floor.

Start counting the pulse immediately at the 15-second mark on the stop watch and count for 15 seconds. Multiply by four and record.

Continue to take pulse in 15-second counts until the rate has returned to the normal standing rate. Note the number of seconds it takes for this to return and record. In computing this return, count from the end of the 15 seconds of exercising to the beginning, of the first 15-second normal standing pulse count. If the pulse has not returned to normal at the end of two minutes, record the number of beats above normal and discontinue counting.

Check up points and enter final rating as indicated in the table. If after repeated tests the circulatory efficiency rating is seven or less,

Table for grading cardiovascular changes

A. Reclining pulse rate		B. Pulse rate increase on standing				
Rate	Points	0-10 beats, points	11-18 beats, points	19-26 beats, points	27-34 beats, points	35-42 beats, points
50-60	3	3	3	2	1	0
61-70	3	3	2	1	0	—1
71-80	2	3	2	0	—1	—2
81-90	1	2	1	—1	—2	—3
91-100	0	1	0	—2	—3	—3
101-110	—1	0	—1	—3	—3	—3

C. Standing pulse rate		D. Pulse rate increase immediately after exercise				
Rate	Points	0-10 beats, points	11-20 beats, points	21-30 beats, points	31-40 beats, points	41-50 beats, points
60-70	3	3	3	2	1	0
71-80	3	3	2	1	0	0
81-90	2	2	2	1	0	—1
91-100	1	2	1	0	—1	—2
101-110	1	1	0	—1	—2	—3
111-120	0	1	—1	—2	—3	—3
121-130	0	0	—2	—3	—3	—3
131-140	—1	0	—3	—3	—3	—3

E. Return of pulse rate to standing normal after exercise

Seconds	Points
0-30	3
31-60	2
61-90	1
91-120	0
After 120: 2-10 beats above normal	—1
After 120: 11-30 beats above normal	—2

F. Systolic pressure, standing, compared with reclining

Change in mm.	Points
Rise of 8 or more	3
Rise of 2-7	2
No rise	1
Fall of 2-5	0
Fall of 6 or more	—1

it is considered sufficient to disqualify.

Enter history of case, including amount of sleep, amount of smoking, kind of work (outdoor or indoor, active or sedentary, etc.), time since last meal, any personal worries, or any pathological condition which might affect the condition of the subject.

INTERPRETATION OF FINDINGS

Blood Pressure.—If the examinee is a candidate for flight training, the systolic blood pressure shall not persistently exceed 135 mm., nor the diastolic pressure exceed 90 mm. In the case of qualified pilots, if the examinee is over 25 years of age, the systolic blood pressure shall not persistently exceed 150 mm. If the examinee is 25 years of age or younger, the systolic pressure shall not persistently exceed 140 mm. A systolic blood pressure of less than 105 mm. disqualifies. A diastolic blood pressure persistently above 95 mm. is disqualifying. Abnormally low diastolic blood pressure should be viewed with concern, particularly with regard to its effect on vasomotor tone while flying. In such cases, the underlying cause should be determined if possible. The condition, if sufficiently marked, may be considered as disqualifying.

Circulatory index.—This index shall be regarded as a valuable check on the physical condition of the examinee. An index below eight shall be regarded as unsatisfactory. No individual shall be rejected because of a single failure to pass the test satisfactorily, but shall be recalled for further observation and study. When the index is persistently below the acceptable limit and is indicative of neurocirculatory asthenia, or other abnormalities of the circulatory system, the examinee shall be disqualified.

Teeth.—Evidence of marked malocclusion, especially when associated with a weak or defective dental arch, or with evidence of extensive caries or loss of teeth, shall be cause for rejection.

Neuropsychiatrical examination.—Following the completion of the general examination, the

examiner shall make a careful study of the examinee's family history for evidence of insanity, familiar traits of psychoneurotic manifestations, degenerations, and inherited deficiencies. The candidate's personal history shall be searched for significant factors which relate to the formative years that affect his personality trend. The infantile period shall be searched for evidence of retardation. Consideration shall be given to examination of the family life, play life, school life, sex life, and a careful search for epileptic equivalents. Determine the family attitude toward flying and the examinee's reaction to the stresses of life and his general emotional response and control. The object of the examination shall be to determine the individual's basic stability and capacity to react favorably to the special stresses encountered in flying. This phase of the examination shall be performed routinely only on applicants for flight training who are otherwise physically qualified.

Neurological examination.—A careful neurological examination shall be made, attention being given to the following examinations and report of findings:

Pupils.—Regular, irregular, equal, unequal, do or do not react to light and accommodation.

Deep sense (Romberg).—Negative, slightly positive or pronouncedly positive.

Deep reflexes.—Patellar, biceps, etc.—Absent (o), diminished (—), normal (+), hyperactive (++), and exaggerated (+++).

Superficial reflexes.—Abdominal, cremasteric, etc.—Any abnormalities found.

Sensory disturbances.—Any abnormalities found.

Motor disturbances.—Evidence of muscle weakness, paresis, or any other abnormality.

Trophic disturbances.—Evidence of atrophy, compensatory hypertrophies, or any other abnormality.

Tremors.—State whether fine or coarse, and name parts affected.

Tics.—Specify parts affected.

Cranial nerves.—Examine carefully for evidence of impaired function or paresis. It should be remembered that some of the cranial nerves are subject to frequent involvement in a number of important diseases, such as syphilis, meningitis, encephalitis lethargica, and injuries to the cranium.

Psychomotor tension.—Ability voluntarily to relax. This shall be tested by having the examinee rest forearm upon palm of examiner and then testing the tendon reflexes of the forearm with a percussion hammer. The flight surgeon should keep himself informed regarding all indications of staleness in order to recognize the earliest manifestations of that condition.

Peripheral circulation.—Examine for flushing, mottling, and cyanosis of face, trunk and extremities. Question as to the presence of localized sweating (armpits and palm) and cold extremities. Any abnormalities disclosed on the neurological examination should be carefully studied and an opinion expressed as to their cause and significance and whether they are sufficient cause for rejection.

21149.5—After the examination has been completed, the examiner shall make an assessment of the individual's qualifications for flying, based upon the physical findings and the result of the neuropsychiatric examination. While no individual will possess all good traits, or all bad ones, the examiner shall summarize his impressions of the individual's aeronautical adaptability, which shall be recorded as favorable or unfavorable. When an individual is found to be physically qualified but his aeronautical adaptability is regarded as unfavorable, the entry of findings on Standard Form 88 as finally recorded, shall be "Physically qualified but not aeronautically adapted." When an individual is found not aeronautically adapted, sufficient comment and information shall be furnished to justify such a conclusion.

21150. VISUAL ACUITY

21150.1—*Apparatus.*—The apparatus for testing visual acuity consists of five Snellen test charts, each with a different arrangement of letters and a blank card about 6 x 9 cm. Four test charts are cut off so that the 20-foot and successive smaller rows of letters are used. The central chart is left fully exposed. The five charts are arranged in close formation against a neutral-colored wall at the end of the examining room and each is numbered. The numerals

must be distinctly visible at a distance of 20 feet. Two 100-watt daylight Mazda lamps with reflectors are installed about four feet above and in front of the test charts to provide uniform illumination. A single 200-watt daylight Mazda lamp in a suitable reflector may be substituted for the above. The switches controlling these lamps and the spotlight used with the phorometer trial frame should be located on the side wall, where they can be reached easily by the examiner as he stands beside the examinee's chair. All windows and other sources of light located in front and to the side of the examinee are shaded during the examination. Other standard appliances acceptable to the Bureau for testing visual acuity may be used in lieu of the apparatus described.

21150.2—*Procedure.*—Upon entering the room, the examinee occupies a chair facing the test charts exactly 20 feet away. In order to prevent study of the letters, the test is begun promptly. The examiner stands at one side of the examinee, using the 6 x 9 cm. blank card to cover the left eye while the right is being tested. Designating one of the small charts by number, the examiner instructs the examinee to read as many letters as possible. When the best vision for the right has been obtained, the card is shifted to cover the right eye and the left eye is tested on one of the other small charts. The large (complete) chart is used only when the vision is less than 20/20. The row of smallest letters read correctly determines the numerator of the fraction used in recording visual acuity. The number of smaller letters read in the next line is added to this fraction following the plus sign; for example 20/20 + 4.

21150.3—*Precautions.*—Every possible safeguard is thrown around the test to prevent memorizing the charts. Examinees awaiting their visual acuity test are not permitted to remain in the room within sight of the test letters or where they can hear them read aloud. When the examinee is suspected of having memorized the charts, the examiner will select letters in the doubtful lines and have the examinee name them. The small charts should be given a different arrangement from time to time in order to prevent memorizing the letters according to the position of the charts on the wall. One eye is completely screened from the letters while the other is being tested. The use of the hand or of an opaque disk from the trial case as a screen does not insure a monecular test.

21150.4 — *Interpretation of findings.* — For candidates for flight training, the minimal visual requirement for each eye is 20/20. For qualified and experienced pilots, visual acuity of not less than 15/20 for each eye unaided by glasses may be permitted when the pilot's experience is sufficient to compensate for this departure from normal vision.

21151. DEPTH PERCEPTION AT SIX METERS

21151.1—*Apparatus.*—Depth perception apparatus may be obtained from the Naval Medical Supply Depot on approved requisition. The apparatus shall be installed in such a manner as to receive adequate illumination without the examinee being subjected to the direct glare of the light.

21151.2—*Procedure.*—The rods in the box are widely separated by the examiner, and the examinee is required to manipulate the two cords so as to bring the movable rod beside the fixed one in such position that both appear to be the same distance from him. The test is repeated several times, the rods being widely separated before each trial. The examinee's estimation of depth difference is read in millimeters directly from the scale and entered on the record. The test shall be conducted at a distance of 20 feet.

21151.3—*Precautions.*—No information concerning the results of the successive trials shall be given the examinee until after the test is completed. The examinee is required to hold his head straight and not to one side or the other. Care shall be taken by the examiner to avoid casting a shadow on the background, to avoid placing the hands so as to give the examinee information as to his error, and to avoid any facial expression from which the examinee might gain information as to the result of his efforts.

21151.4 — *Interpretation of findings.* — An average depth difference of more than 30 mm. in five readings disqualifies. An erratic result shall necessitate an examination the following day and if still erratic shall disqualify until consistently below 30 mm.

21152. THE MADDOX-ROD SCREEN TEST AT SIX METERS

21152.1 — *Apparatus.* — A photometer trial frame equipped with a pair of multiple Maddox rods and a pair of Risley rotary prisms, a blank card about 6 x 9 cm., which serves as a screen, and a blank card about 13 x 20 cm., with a 3-cm. hole in its center, shall be used.

21152.2—*Procedure.*—Before beginning the test, determine the examinee's fixing eye. For this purpose the 13 x 20 cm. card is employed. The examinee, seated, facing the spotlight six meters away, grasps the card by the long sides with both hands. While looking intently at the light, he slowly raises the card at arm's length and locates the light through the hole without closing either eye. Only one eye can see the light through the hole, and the eye selected for this purpose is the one used habitually for sighting or fixing. The photometer trial frame is now properly leveled and adjusted closely in front of the examinee's eyes.

One of the multiple Maddox rods is swung into position before the non-fixing eye. A rotary prism is placed before the same eye. The sighting or fixing eye must have an unobstructed view of the spotlight. For the measurement of esophoria or exophoria, the Maddox rod is adjusted before the nonsighting eye to give a vertical line of light. The rotary prism is adjusted also before the nonsighting eye for the measurement of lateral deviation and set four or five prism diopters off the zero mark. This gives enough deflection at the first reading to detect an examinee who has been coached to say the line passed through the light. The 6 x 9 cm. card is moved from one eye to the other a few times to ascertain if the examinee sees both line and the light.

If the line is not seen readily, the Maddox rod is readjusted by centering it carefully in front of the pupil. Some further darkening of the room may be necessary to render the rod clearly visible. When the examinee sees the line with one eye and the light with the other, the examiner holds the card or screen in front of the nonfixing eye to shut out the image of the line. The examinee now sees only the light. After he has fixed it for several seconds, the screen is removed for an instant and quickly replaced. In that brief interval the examinee will be able to see the line and locate it in reference to the light.

After one or two such exposures, he will say that the line is to the right or left of the light or possibly through it. He is instructed to grasp the milled head that rotates the prism and turn it to bring the line directly into the light. To enable him to do this, the screen is removed from the eye at intervals and quickly replaced. Finally, the examinee will have rotated the prism enough to cause the line to pass through the light every time the screen is removed. The number of prism diopters necessary to do this is read from the scale of the rotary prism. This is entered on the record as esophoria if the prism is base out, and exophoria if the prism is base in.

For the measurement of hyperphoria, the Maddox rod before the nonfixing eye is readjusted to give a horizontal line of light. The rotary prism is also readjusted before the same eye to measure vertical deviation. The screen is used exactly as before to give an occasional glimpse of the line. The number of prism diopters read from the scale is recorded as right hyperphoria if the prism is base down before the right eye, or base up before the left. It is recorded as left hyperphoria if the prism is base up before the right eye or base down before the left. In testing for hyperphoria, the Stevens' frame which is normally a part of the phorometer mechanism, should be used instead of the larger prisms. The Stevens' frame attachment is composed of weaker prisms which are calibrated in tenths of a diopter and therefore permit more accurate readings for hyperphoria.

21152.3—*Precautions.*—The Maddox rod and the measuring prism are always used together before the nonfixing eye and never before the fixing eye. The test gives an inaccurate result if the examinee is permitted to see the line for a longer time than is allowed by the momentary flash exposures described above.

21152.4—*Interpretation of findings.*—Esophoria of more than 4 D., if associated with a prism divergence of less than 4 D., disqualifies,

even though the red lens test shows no evidence of diplopia. Esophoria of more than 10 D. disqualifies even if unassociated with any other visual defect. Exophoria of more than 5 D. disqualifies. Hyperphoria of more than 1 D. disqualifies.

21153. PRISM DIVERGENCE

21153.1—*Apparatus.*—The phorometer trial frame and the rotary prism with a spotlight 1 cm. in diameter at a distance of 13 inches from the eyes shall be used.

21153.2—*Procedure.*—The procedure shall follow paragraph 2124C.

21153.3—*Interpretation of findings.*—A prism divergence of less than 12 diopters is disqualifying. An excessive amount of prism divergence (above 22 diopters) should be accompanied by a disqualifying amount of exophoria.

21154. RED LENS TEST

21154.1 — *Apparatus.* — A spectacle trial frame, a red lens from the trial lens case, a small light such as an ophthalmoscope without head, and metric rule or tape shall be used.

21154.2—*Procedure.*—The examinee is seated in the darkroom facing the dark wall or tangent curtain at 75 cm. distance. The spectacle trial frame is adjusted into position and the red lens from the trial lens case is placed in one cell of the trial frame. With the examinee's head in a fixed position, the small lamp is held directly before the dark tangent curtain at 75 cm. distance from the eyes. The presence or absence of diplopia in this position (primary) is noted. The light is then slowly moved from the central position toward the right for a distance of 50 cm. in the horizontal plane. In the same manner the light is moved in the remaining five cardinal directions, up and to the left, to the left, down and to the left, and down and to the right. The presence or absence of diplopia in any of these positions should be noted. Normally, diplopia should not occur in any meridian within 50 cm. of the primary or central position. In the presence of diplopia, notation should be made as to whether it is crossed, honomomous, or vertical, and the distance in centimeters from the central position that diplopia occurs should be recorded. When diplopia is suspected and the examinee has been coached to deny its presence, a prism of 3 or 4 D. may be placed, either base up or base down, in one cell of the trial frame, and if diplopia is still denied, the statement is obviously untrue.

21154.3—*Precautions.*—The head of the examinee must remain fixed and the movement of the light followed only by the eyes. No tilting or rotation of the face shall be permitted.

21154.4—*Interpretation of findings.*—Diplopia within 50 cm. of the primary position, in any meridian, disqualifies.

21155. TEST OF ASSOCIATED PARALLEL MOVEMENTS

21155.1—*Apparatus.*—A pin with a white head 2 mm. in diameter shall be used.

21155.2—*Procedure.*—The examinee stands near a window where good illumination falls on both eyes. The examiner holds the white headed pin about 33 cm. directly in front of the examinee's eyes and directs him to look at it steadily. Nystagmus in the primary position is to be noted at this stage of the test. The examinee is then instructed to hold his head still and watch the pin as it is moved slowly to his right. The pin is not carried beyond the field of binocular fixation, but is held motionless for a moment near the lateral limit of the field. Each eye is inspected to discover any failure in fixing the pin. The lagging or overaction of either eye is noted. The pin is then carried slowly to the extreme left, up and to the left, straight up, up and to the right, to the extreme right, down and to the right, straight down, and down and to the left. The lagging of either eye in any of these eight cardinal directions is due to underaction of at least one of the extrinsic ocular muscles. The underaction is recorded by stating which eye lags and in which direction the lagging is observed. In the same way any overshooting of either eye is recorded by stating which eye is involved and in which direction. If any underaction or overaction is revealed by this test, the final diagnosis shall be made on the tangent curtain by means of the red lens test.

21155.3—*Interpretation of findings.*—The ex-

aminee is disqualified if the underaction or overaction of any of the extrinsic ocular muscles results in heterophoria at six meters in excess of normal limits, or produces diplopia within 50 cm. of the primary position in any meridian as determined by the red lens test.

21156. INSPECTION OF THE EYES

21156.1—*Procedure.*—Whenever possible, the eyes are inspected by bright daylight. Every pathologic condition and congential anomaly is recorded. The following conditions may be found by this procedure:

1. Lids: Ptosis, blepharitis, trichiasis, entropion, ectropion, and chalazion.
2. Tear Sacs: Imperfect drainage.
3. Lower Puncta: Failure of contact with bulbar conjunctivae.
4. Conjunctivae: Trachoma and old scars.
5. Corneas: Scars, pannus, and pterygium.
6. Pupils: Unequal size, irregular shape, and failure to react to light or accommodation.

21156.2 — *Interpretation of findings.* — Any pathologic condition which may become worse or interfere with the proper functioning of the eyes under the fatigue and exposure of flying disqualifies.

21157. TEST FOR ACCOMMODATION

21157.1—*Apparatus.*—The Prince rule, a small millimeter rule, and a card with several rows of small letters shall be used.

21157.2 — *Procedure.* — Accommodation is measured from the anterior focus of the eye, which is about 11.5 mm. in front of the cornea. Using the millimeter rule, make a pencil mark on each side of the examinee's nose 11.5 mm. in front of the right and left cornea respectively. In measuring the accommodation of the right eye, lay the flat side of the Prince rule against the right side of the examinee's nose, with the end of the rule at the pencil mark. The rule is held horizontally and extends directly to the front, edge up. The card of test letters is held not more than 5 cm. in front of the examinee's right eye. His left is screened from sight of the letters by the flat side of the rule. The card of test letters is now carried slowly away from the eye and the examinee instructed to begin reading the letters aloud as soon as they become legible. The card is halted the instant he begins to read the letters correctly and the point on the rule opposite the card is read off in diopters. This is the measure of accommodation of the right eye. To test the left eye, change the rule to the left side of the nose and repeat the above procedure, using a different line of letters.

21157.3 — *Precautions.* — The examinee is placed with his back to good light, with the card well illuminated. The card is started from close to the eyes and carried away from them. The letters on the test card are read aloud. The same line of letters is not used for testing both eyes.

21157.4—*Interpretation of findings.*—The following table gives the mean values of accommodation in diopters from 18 to 50 years of age. Accommodation may be regarded as within normal limits provided it is not more than 3 D. below the mean for the examinee's age. The examinee is disqualified if his accommodation falls more than 3 D. below the mean for his age, but before an examinee is disqualified, his accommodation shall be taken on three successive days and an average of the three findings determined. Accommodation may be affected by fatigue, staleness, or other debilitating conditions.

Age	Diopters	Age	Diopters	Age	Diopters	Age	Diopters
18	11.9	24	10.4	30	8.9	36	7.1
19	11.7	25	10.2	31	8.6	37	6.8
20	11.5	26	9.9	32	8.3	38	6.5
21	11.2	27	9.6	33	8.0	39	6.2
22	10.9	28	9.4	34	7.7	40	5.9
23	10.6	29	9.2	35	7.3	45	3.7
						50	2.0

21158. ANGLE OF CONVERGENCE

21158.1—*Near point of convergence* (*PcB*). —The Prince rule and a pin with a white head 2 mm. in diameter shall be used. The distance to the near point of convergence is computed from the base line connecting the centers of rotation of the eyes. The end of the Prince rule is placed, edge up, at the mark on the right side of the nose, 11.5 mm. in front of the cornea. The white-headed pin is held 33 cm.

away in the median line above the edge of the rule and the examinee is instructed to look at it intently. If both eyes are seen to converge upon the pin, it is then carried in the median line, along the edge of the rule, toward the root of the nose. The examinee's eyes are carefully watched and the instant one is observed to swing outward the limit of convergence has been reached. The point on the rule opposite the pin is then read in millimeters. This test is repeated until a fairly constant reading is obtained. To this reading 25 mm. is added, which will give approximately the distance from the near point of convergence to the base line, PcB. Both eyes must converge upon the pin at the start of the test. The examinee's observation of the onset of diplopia is not relied upon to determine the near point, although he is asked to state when he sees double. The near point of convergence, unlike the near point of accommodation, varies little with age. Its measurement is of value only in computing the angle of convergence. Examinees are not qualified or disqualified on this measurement, but on the angle of convergence.

21158.2—*Interpupillary distance* (*Pd*).—A small millimeter rule is used. The examiner stands with his back to the light, face to face with the examinee. The rule is held in the examiner's right hand and laid across the examinee's nose in line with his pupils, as close to the two eyes as possible. The examiner closes his right eye and instructs the examinee to fix his eyes on the open left eye. With the eyes in this position, a predetermined mark on the rule is placed in line with the nasal border of the examinee's right pupil. The rule must be held steadily in this position while the examiner opens his right eye and closes his left. The examinee is then instructed to look at the open right eye. The point on the rule in line with the temporal border of the examinee's left pupil is read in millimeters and the exact difference in millimeters between the two points on the rule is the interpupillary distance.

21158.3—*Computing the angle of convergence.*—The following formula is used for computing the angle of convergence:

$$\text{Angle of convergence} = \frac{\tfrac{1}{2}\text{Pd X } 100}{\text{PcB}} + 3$$

An angle of convergence of less than 40° is undesirable, but is not disqualifying unless associated with excessive exophoria, or diplopia on the tangent curtain. Diplopia in the extreme positions on the tangent curtain shall not be considered disqualifying.

21159.—*Central color vision.*—Color vision shall be tested by means of the American Optical Company Pseudo-Isochromatic Plates for Testing Color Perception, 1940. The examinee is placed with his back to good light (natural light is preferable) in such a manner as to insure that the plates of the chart are illuminated and free of shadow. The plates are exposed to the examinee, who is required to call the numbers or letters indicated in the colored chart. The examinee may be permitted to tilt or alter the position of the charts to improve the light. The instructions in the A. O. C. chart book shall be followed, and the requirements of paragraph 2125.3 as modified by BuMed Circular Letter No. 46-177 shall apply.

21160. FIELD OF VISION

21160.1—The examiner faces the examinee at a distance of 2 feet. He instructs the examinee to close his left eye and to fix his right eye on the examiner's left eye, the examiner's right eye being closed. The examiner then brings his moving fingers in from the periphery midway between them. The examinee is instructed to say when he sees the fingers, and how many. He should see them as soon as the examiner, if normal. The fingers are brought in from all cardinal directions. The test is then repeated for the left eye. Any evidence of abnormality should be given detailed study on the perimeter.

21160.2—The field of vision for each eye shall be normal as determined by the finger fixation test. When there is evidence of abnormal contraction of the field of vision in either eye, the examinee shall be subjected to perimetric study for form and color. Any contraction of the form field of 15° or more in any meridian shall disqualify.

21161. REFRACTION

21161.1—Refraction of the eyes shall not be required on original or routine examination,

but shall be performed in special cases only, when so indicated. An electric retinoscope, or a plain retinoscope and a wall lamp, a trial case and trial frame, Snellen test type, and a cycloplegic shall be used.

21161.2—The tension of both eyes must be taken by palpation and found normal before instilling a cycloplegic. The fundus of both eyes must also be examined with the ophthalmoscope, and if evidence of glaucoma are found a cycloplegic shall not be used. One drop of a 4 percent homatropine solution is placed in each eye every 10 minutes until four instillations have been made. At the end of one hour from the time of the first instillation, the examinee is ready for refraction. Retinoscopic examination is conducted in the darkroom and the results of the refraction are then verified by having the examinee read the Snellen charts. The minimum correction required to enable the examinee to read 20/20 each eye is recorded, together with the true correction as determined by retinoscopy.

21161.3—The examinee is disqualified if he requires more than 2 D. total correction in any meridian in order to read 20/20 each eye with the accommodation paralyzed. Of this allowable correction not more than a total of 0.5 D. shall be due to any form of myopia or astigmatism or any combination thereof.

21161.4—After the use of a cycloplegic the examinee must wear dark glasses until the effects have disappeared. The instillation into each eye of a 1 percent solution of pilocarpine hydrochloride in distilled water will contract the pupil and thus relieve the photophobia.

21162. OPHTHALMOSCOPIC EXAMINATION

21162.1—The examination shall not be required on original or routine examination, but shall be performed in special cases only, when so indicated. The examination must not be made before the refraction is completed. In examining the macular region of the retina, the light should be reduced and the exposure made as brief as possible.

21162.2—Any abnormality disclosed on ophthalmoscopic examination that materially interferes with normal ocular function disqualifies. Other abnormal disclosures indicative of disease, other than those directly affecting the eyes, shall be considered with regard to the importance of those conditions.

21163. EAR

21163.1—*General.*—The external auditory canals and membranae tympani are examined by means of a speculum and good light. Wax interfering with a good view of the tympanum must be removed from the external auditory canal. If internal to the bend of the canal; the canal should be filled with a bland oil and blocked with cotton. The following day thorough washing of the external canal with a solution of sodium bicarbonate will remove the wax. The external canal is then examined throughout. Any serious permanent blocking of the canal or diseased condition which threatens trouble later, such as the impairment of hearing, disqualifies. The membranae tympani are then examined. A perforation or evidence of present inflammation disqualifies. The presence of a small scar, caused by trouble several years previously which has not recurred and with which there is no deficiency of hearing and no evidence of other inflammation, does not disqualify. Marked retraction of a drum membrane, following chronic ear disease, disqualifies.

21163.2—*Hearing tests.*—Hearing should be normal for each ear. To determine this the following tests shall be used. A quiet room is essential.

Whispered-voice test.—The examinee should stand 15 feet from the examiner with the ear being tested turned toward him, the other ear being covered or closed. The examiner, after full expiration, will whisper a number or word and require the examinee to repeat it after him. Each ear shall be tested in turn. If the examinee is unable to hear at 15 feet, the examiner shall approach until he is able to distinguish the words or numbers the distance being recorded in feet with 15 as the denominator.

Clock test.—The clock test should be made using the standard ward desk clock, Stock No. 7-754-700, *Catalog of Navy Material,* BuMed Section according to the instructions of paragraph 2130. The distance in inches at which the clock is heard by the examinee, with eyes

closed and opposite ear occluded, is taken as the numerator and the distance the clock should be heard as the denominator. Hearing by this test should be equivalent to 40/40.

Coin-click test.—An assistant closes the ear not under examination. The examiner, 20 feet back of the examinee, then clicks two coins softly together and the examinee is directed to count, aloud, the number of clicks each time. The other ear shall then be tested in a similar manner. If the candidate is unable to hear the click, the examiner will approach until he does hear, the distance being recorded in feet. Hearing by this test should be equivalent to 20/20.

21163.3—If the examiner is convinced from the results of the several tests that definite impairment of hearing exists, he shall reject the examinee if he is an applicant for aviation training. In case of a qualified flyer, however, due allowance shall be made.

21164. NASO-PHARYNX

In the examination of the naso-pharynx the examiner shall, in general, be guided by the instructions and requirements prescribed for the general service as outlined in paragraphs 2148 and 2149 of this chapter. Any abnormality disclosed on examination indicating an estimated 50 percent or more of nasal obstruction, acute or chronic sinusitis, acute or chronic tonsillitis, nasal blockage, mechanical obstruction to drainage of accessory sinuses, occlusion of one or both eustachian tubes, or other abnormalities which may seriously interfere with normal function, shall be cause for rejection.

21165. EQUILIBRIUM (VESTIBULAR) TESTS

21165.1—*Barany chair test.*—The nystagmus and falling after turning are tested, when practicable, on original examination and when otherwise indicated. Where facilities are not available, or circumstances do not permit of the test, then the examination shall be limited to the self-balancing test as outlined below. Inasmuch as the self-balancing test is in effect a modified Romberg test, all examinees shall undergo that test as a regular part of their examination.

21165.2—*Nystagmus.*—Examinee's head is inclined 30° forward, so that the tragus of the ear is on a horizontal line with the external canthus of the eye. The examinee is then asked to fix his eyes on a distant point and the chair turned slowly from side to side in order to note whether or not spontaneous nystagmus is present. Then turn the examinee to the right, with eyes closed, 10 times in exactly 20 seconds. The instant the chair is stopped, click the stop watch; the examinee opens his eyes and looks straight ahead at some distant point. There should occur a horizontal nystagmus to the left of 26 second duration. A variation of 10 seconds above or 12 seconds below is allowable.

21165.3—*Falling.*—The examinee's head is inclined 90° forward, resting his forehead on his upper fist, his fists being placed one above the other on his knees, which are brought close together. He should then be turned to the right, five times in 10 seconds. On stopping, the examinee raises his head and should fall to the right. This tests the vertical semicircular canals. The examinee should then be turned to the left, his head forward 90°; on stopping, he raises his head and should fall to the left.

21165.4—*Self-balancing test.*—The applicant stands erect, without shoes, with heels and large toes touching. He then flexes one knee to a right angle, being careful not to support it against the other leg, closes his eyes, and endeavors to maintain this position for 15 seconds. The test is then repeated on the other foot. The findings are recorded as *Steady, Fairly Steady, Unsteady,* or *Failed.* The applicant should be instructed that this is the equilibrium test. There is no objection to his assisting his balance by moving and bending back and forth.

21165.5—*Interpretation of findings.*—Inability to pass the tests for equilibrium satisfactorily shall be cause for rejection.

CHAPTER 11

AVIATION DENTISTRY *

Aerodontalgia is the term applied to dental pain resulting from a decrease in atmospheric pressure.

In dealing with pain, it is necessary to discuss the part responsible for its action, namely, the dental pulp. The dental pulp may be defined as the connective tissue occupying the central cavity of a tooth. It is composed of embryonal connective tissue which is more closely related to the tissues occupying the spaces of cancellous bone than to any other tissue. So we have as the structural elements of the dental pulp the odontoblasts, connective-tissue cells, intercellular substance, blood vessels, nerves, and lymphatic vessels.

Pain registering on the teeth is carried to the brain by the fifth cranial nerve. All of the maxillary teeth are supplied by the second or superior maxillary division of this trigeminal nerve, which further branches into the posterior superior dental, middle superior dental and anterior superior dental nerves. The mandibular teeth are supplied by the third or mandibular division.

The functions of the pulp are the formation of dentin, the main bulk of a tooth—in the embryonic developmental stage—the reproduction of a limited amount of dentinal material for the protection of the pulp in various destructive conditions such as dental caries, and sensory function responding to thermal and chemical change and traumatic irritation.

The sensory function of the pulp resembles an internal organ in that in its normal condition it is always inclosed in the cavity of a tooth. If a situation could be created where by only the pulps of the teeth on one side of the median line of both the maxillary and mandibular arch were exposed and a stimulus applied to the pulp of one tooth, it would be impossible for the patient to say which pulp had been touched. This creates a difficult problem in diagnosis, particularly in conditions where there may be complications between the maxillary teeth and the maxillary sinus, as in locating the tooth producing the pain when it is not clinically obvious.

The pulp is an extremely vascular tissue and the arrangement of the vessels, the structure of their walls, and the nature of the intercellular substance through which they run render the tissue especially susceptible to the pathological conditions associated with alterations in the circulation. This is due primarily to the very minute foramina in the apex of a tooth. In other parts of the body, when damage has occured there is always some room for the tissues to swell and make room for increased flow of the repair vessels, but in a tooth all repair is limited to the size of the apical foramen which is a calcified structure not amenable to any pathologic condition. Therefore, any traumatic pressure sufficient to cause swelling or severance of the vessels in the apex of the tooth will cause the tissue to die.

Although, many of these chronic devitilized, teeth are painless at sea level barometric pressure they will liberate gas and cause pain at low pressure.

Other causes of aerodontalgia have been attributed to: carious teeth; recently filled teeth; teeth filled with insufficient insulating base material when in close proximity to the pulp. Radiographic examination will reveal many of these potential causes to the dental officer.

As stated above, because of the relation of the maxillary teeth to the maxillary sinus, in

* Prepared by Cdr. E. E. Jeansonne, D.C., USN.

some cases the apices of the posterior teeth extend the floor of the sinus upward and there can be doubt as to where the pain and infection is located.

Cases of aerotitis media have been attributed to abnormalities of the temporo-mandibular joint. These conditions, such as impaired hearing, stuffy sensation, and dull pain in the ears have been attributed to a loss of intermaxillary distance or over closure of the mandible. The posterior teeth and the muscles of mastication maintain the normal distance, but where there has been a loss of teeth or loss of tooth structure from excessive wear or malocclusion the intermaxillary distance is changed. This will produce some change in the position between the condyle of the mandible and the glenoid fossa of the temporal bone. Usually the condyle moves upward and backward, possibly causing pain from pressure on the auriculo temporal nerve.

Loss of maxillary distance may cause compression of the eustachian tubes by relaxation of the external pterygoid muscle producing excessive tissue in the region of the tubes. Costen has stated, "when this is done manually the tensor veli palatine muscle bordering the membranous anterior edge of the eustachian tube and the adjacent sphinomeniscus muscle are seen to wrinkle and crowd the eustachian tube, closing it firmly. During the act of swallowing the tensor veli palatini muscle should be tense and effect a temporary opening to the tube. This function cannot occur during overclosure and the result is derangement of intratympanic pressure".

A study of aviators with overclosure cases with correction by prosthetic interdental splint was made by Lowery at N.A.S., Pensacola in 1939. The statistics of his report of 540 aviators showed that 83, or 15 percent, had loss of vertical dimension. Thirty-three, or 39 percent of the 83 persons with loss of vertical dimension gave histories of faulty ventilation of the tympanum. This was 6 percent of the 540 examined. The 33 cases with loss of vertical dimension gave symptoms of discomfort and inability to readily equalize pressure on the tympanum, pain tinnitis and impaired hearing. Splints to lengthen the vertical dimension were constructed for 31 of the 33 cases, two did not wish them. After becoming accustomed to wearing them they were used in actual flight from six months to one year. Twenty-six persons submitted written reports on the effectiveness of the splints, five made no reports. The reports showed nine persons, or 34 percent, relieved of all distressing ear symptoms, 14 persons or 53 percent benefited by its use, three derived no beneficial results.

An observation made on "Toothache and the Aviator" at N.A.S., San Diego by Joseph and others over a period of six months revealed an incidence of toothache in 1.2 percent of cases. They found that tooth pains had no particular relationship to specific altitude, beyond the fact that the greatest number of pain reactions occurred at the highest altitude reached. Fifty-seven percent of cases experienced pain at 28,000 feet, 23 percent at 18,000 feet and the remaining twenty percent at 10,000 feet or below. About half of the men reported their toothache as a sharp pain, while the other half complained of a dull ache.

BIBLIOGRAPHY

Dental Histiligy and Embryology—Noyes, F. B.

A Syndrome of Ear and Sinus Symptoms Dependent upon Disturbed Functions of the Temporomandibular Joint—Ann, Otol, Rhin and Laryng. 43:1 (March) 1934—Costen, J. B.

"*Loss of* Intermaxillary Distance: Effect on Aviators and Relief by Interdental Splint," *U. S. Nav. Med. Bul.* 37:367-380 (July) 1939—Lowery, R. A.

Toothache and the Aviator—Joseph, T. V.; Gell, C. F.; Carr, R. M.; Shelesnyak, M. C.

"Experimental Investigation of the Referred Pain of Aerodontalgia"—*Journal of Dental Research.* February, 1947—Hutchins, H. C.; Reynolds, O. E.

QUESTIONS

1. Name the structural elements of the dental pulp.
2. Why does the dental pulp fail to recover under most pathologic conditions?
3. Describe the effect caused by overclosure of the mandible at low pressure.
4. What is the percentage incidence of aerodontalgia?

DENTAL STANDARDS

Summarized from BuMed Circular

Letter No. 48-131, 23 November 1948, are given below:

Standards for enlistment and reenlistment in the regular Navy and class V-6 Naval Reserve:

Applicants must be well nourished and have good musculature, be free from gross dental infections and have a minimum requirement of an endentulous upper and/or an edentulous lower jaw corrected or correctible by a full denture or dentures.

Standards for qualification for appointment as commissioned and warrant officer, USN and USNR, = *Manual of the Medical Department* U. S. Navy paragraph 2150.2 (formerly standards for enlistment) and paragraph 2151:

Applicant must have a minimum of 18 vital, serviceable, permanent teeth and must have sufficient teeth in functional occlusion to insure satisfactory incision and mastication.

The applicant must not require immediate dental prosthesis.

Since a change in status from enlisted to officer grade is an appointment and not a promotion, medical examining boards may not find candidates physically qualified on the basis of ability to perform the duties of the grade for which examined when requirements for commission are not met. It is proper, however; for boards to certify that the candidate's inability to meet the required dental standards is not sufficient to disqualify, and to recommend him for appointment, when the candidate, in the opinion of the board, has other qualifications which are notably higher than average (Secs. 864 and 867, *Naval Courts and Boards*).

Standards to qualify for appointment as midshipman, USN, for the U. S. Naval Academy, midshipman and contract student U. S. Naval Reserve Officers Training Corps, midshipman Merchant Marine Academy, and other officer training programs: paragraph 2152.2 *Manual of the Medical Department*, U. S. Navy:

A candidate for appointment as midshipman must have a minimum of 20 vital, serviceable, permanent teeth including (a) 4 molars. Of this number, 1 upper and 1 lower molar on the right side, and 1 upper and 1 lower molar on the left side must be in functional occlusion; (b) 4 incisors. Of this number, 2 should be in the maxillae and 2 should be in the mandible in such position as to enable the applicant to incise satisfactorily. The teeth must be free from dental caries, restorations must be of high quality, and the peridontal tissues must be free from disease. A candidate should not be acceptable who has teeth missing in the anterior part of the mouth which have not been replaced and which result in an unsightly space. Any deviation from normal occlusion should be minor, and good functional occlusion as well as absence of interference with speech must be demonstrable. Candidates should not be considered qualified for appointment when orthodontic appliances are attached to teeth for the purpose of continued treatment. Orthodontic retaining appliances such as are used after the completion of treatment are acceptable provided they are not an oral health hazard.

Standards for enlistment or reenlistment in the Marine Corps—paragraph 2150 *Manual of Medical Department*, U. S. Navy:

The teeth and mouth shall be examined by a dental officer, if one is available.

To be accepted for enlistment an applicant must have a minimum of 18 vital, serviceable, permanent teeth and must have sufficient teeth in functional occlusion to insure satisfactory incision and mastication. The applicant must not require immediate dental prosthesis.

In order to be accepted for enlisted as a bugler, trumpeter, or musician playing a wind instrument, an applicant, as well as meeting the standards in 2150.2 must have, in serviceable condition, the six upper and the six lower anterior teeth; namely, right and left central incisors, right and left lateral incisors, and right and left cuspids, none of which may be markedly out of alignment or rotated sufficiently to present other than a labial surface of the lip.

The explanation of standards in paragraph 2153 shall apply in interpreting the above requirements.

General Examination for Aviation; Instructions and Requirements. Paragraph 21149.4 (e) Manual of the Medical Department, U. S. Navy:

Candidates shall conform to the following standards: *Teeth.*—Evidence of marked malocclusion, especially when associated with a weak or defective dental arch, or with evidence of extensive caries or loss of teeth, shall be cause for rejection.

CHAPTER 12

OPERATIONAL PROBLEMS IN AVIATION MEDICINE*

This chapter deals with problems encountered by the flight surgeon in aviation operational activities. The solution to these problems is characterized by the necessity of close liaison between the flight surgeon and the aviator. Discussed in this chapter are the following subjects: (1) air-sea rescue and survival, (2) air transportation of patients, and (3) aviation safety.

AIR-SEA RESCUE AND SURVIVAL

RESCUE ORGANIZATION

Mission of an Air Sea Rescue Organization.—The primary mission of air-sea rescue is to render emergency assistance to aircraft and vessels in distress and to rescue survivors thereof. It includes assistance and rescue operations, distress communication procedures and distress flight control, survival methods and equipment, and the indoctrination of personnel in these matters.

Corollary missions are:

1. To save manpower valuable to the military services. The rescue of one highly trained airman saves not only his life, but also the time and expense required for his replacement.

2. To improve the morale of airmen and seamen. Nervous tension decreases considerably when airmen feel that should they be forced down at sea, there is a maximum chance of their being rescued.

3. To relieve training and operational units of such search and rescue operations as may interfere with or divert them from their primary missions.

Necessity for Organized Operations.—Where over-water flying is limited in amount and localized in nature, it is generally true that locally furnished rescue facilities are adequate. If the volume and extent of over-water aircraft operations increase in a particular area the need for an organized air sea rescue service becomes imperative. In those areas where air sea rescue organizations are established statistics show a considerable increase in the percentage of lives saved.

Elements of Operational Organization.—Air-sea rescue organizations established by the Army and Navy vary in detail but all have the common element of centralized control. However, for purposes of illustration, the basic elements of a typical air-sea resuce organization are outlined:

Rescue Operations Center:
- To centralize information
- To exercise emergency flight control when necessary
- To direct primary rescue facilities
- To coordinate secondary rescue facilities.

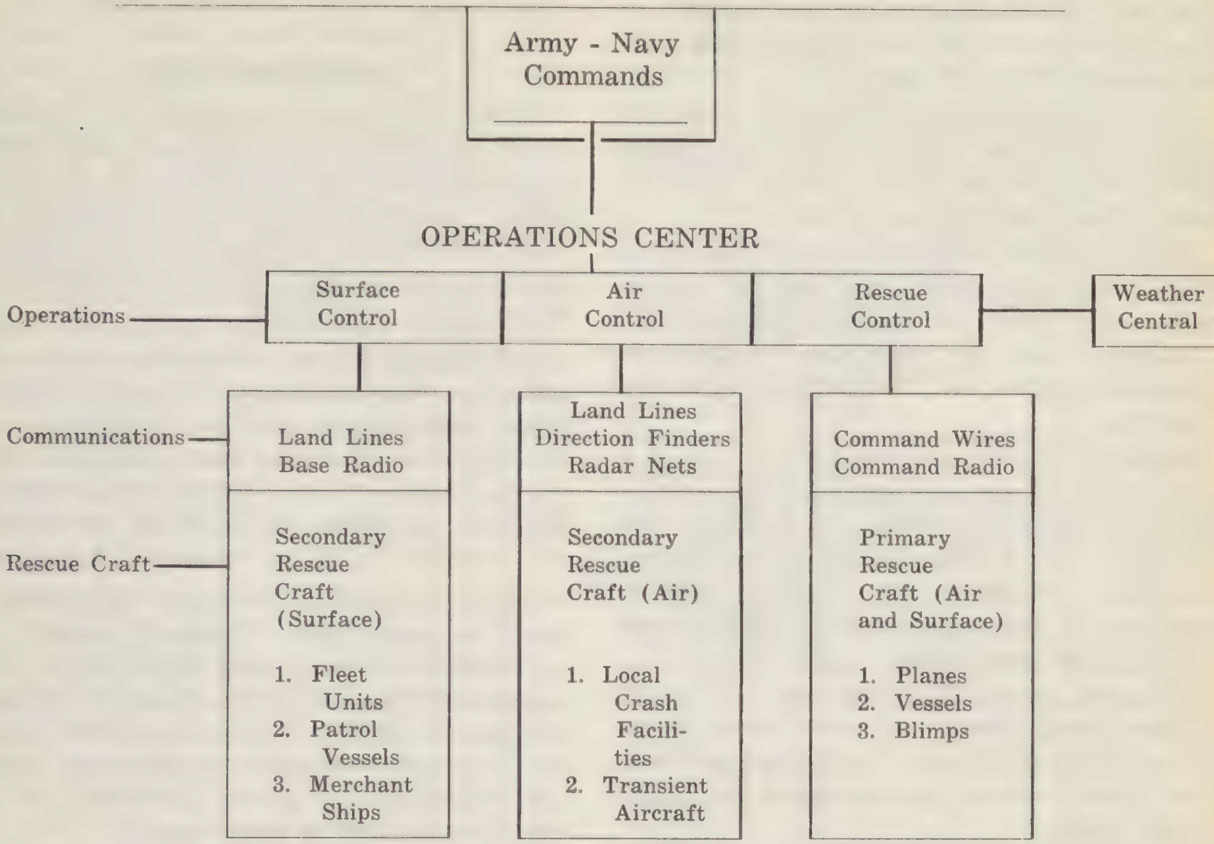
Communication Net:
- To receive and relay distress and crash information
- To expedite and direct rescue operations
- To establish position of aircraft or vessels in distress
- To facilitate emergency flight control.

Rescue Craft, Surface and Air, including —
- Primary facilities — established and maintained for the primary purposes of engaging in rescue operations. Secondary facilities — any other units which may be available for air-sea rescue as an incidental mission.

Rescue operations center.—A rescue operations center may be any office where distress information is pooled, communications are handled, and rescue operations are directed. It is land-based where practicable, but in ocean

* Prepared by Cdr. M. T. Martin, (MC), USN.

DIAGRAM OF IDEAL AIR SEA RESCUE OPERATIONAL ORGANIZATION



areas may be on board a ship underway. Generally, rescue operations can be run best from an existing centralized command or operations center having adequate communication facilities. That is, a rescue operations center should be an integral part of an organization having full knowledge of all air and surface operations in the area.

Air control maintains a current record of aircraft in flight throughout the area for tactical reasons and for purposes of instituting rescue proceedings promptly where an aircraft is overdue, and diverting aircraft which may be of possible assistance in an emergency.

Air control, when required, exercises emergency flight control of aircraft lost or potentially distressed, utilizing all available radar and direction finder facilities.

Surface control maintains a current record of all surface ships and submarines operating in the area. This plot is to provide immediate information on locations of vessels which may be of assistance in rescue operations.

Rescue control should be close to air control, preferably part of the same office. If rescue control cannot be incorporated within air control, rapid intercommunication between the offices is provided. Rescue control should:

Maintain a location and availability board showing all primary and secondary rescue facilities.

Receive and evaluate all distress information and take positive action toward rendering assistance.

Plot the position of all distress incidents and the tracks of all assisting planes and vessels.

Direct and coordinate search and rescue operations.

Keep posted on weather and sea conditions and other factors affecting rescue.

Communication nets.—Air Control keeps complete and adequate communication lines with all military and civil air fields in the area, for rapid transmission of flight plans and distress information. This circuit usually consists of teletype command telephone, CAA

inter-com, and radio. Air control has cognizance over all direction finder and radar networks, including coverage on medium and high frequencies, VHF, and radar.

Surface Control should have direct telephone-teletype connections with all surface operating bases in the area, as well as a base radio for communication with vessels at sea.

Rescue control must have direct communications, preferably telephone, with all rescue craft at their bases, for standby purposes; also a command radio for controlling rescue craft in activated status, and for coordinating rescue operations.

Rescue craft.—Primary rescue craft are specially equipped air and surface craft, maintained in constant readiness, on full-time air-sea rescue duty. Lighter-than-air craft are also specifically designated for rescue purposes. Other vessels may be specifically detailed and assigned to air-sea rescue.

Secondary rescue facilities may be: Local air base, ready planes, and crash boats; Transient aircraft suitable for rescue missions; fleet units; patrol vessels; and merchant ships and private vessels.

Rescue crcaft designated as primary facilities are deployed throughout the area to provide adequate coverage, and to minimize time required for arriving at a particular distress position. Planes and boats must be manned and equipped to carry out rescue missions expeditiously, and to function as a team, utilizing each other's capabilities with regard to speed, range, methods of search, and rescue. It is essential that planes and boats be organized and dispatched collectively as rescue squadrons or task units to facilitate standardization of procedures, equipment, and training.

Air-land rescue organization.—In land areas where flying is concentrated, the same principle of centralized control of rescue forces is indicated. On the coasts it is advantageous to exercise direction over both land and sea rescue facilities from the same point, since aircraft, amphibious vehicles, and other equipment frequently can be used interchangeably.

Air-land rescue facilities are composed of highly trained mobile units, located at strategic spots, and capable of being moved by air to the locality where such facilities are needed within a given area.

RESCUE PROCEDURES

Principles.—Basic principles of successful rescue operations require planned methods for: anticipating distress incidents when operations permit; promptly reporting and relaying distress information; promptly dispatching adequate assistance; and following through rescue operations to completion.

Delivery of distress information requires an adequate communication system. The dispatching of assistance is a matter of doctrine; usually at least one rescue plane and one rescue vessel should proceed immediately, notwithstanding any other action which has been or will be taken. Speed is paramount throughout.

Rescue aircraft and vessels operate as a group to accomplish a common mission, and the essence of successful operation is close teamwork. The primary purpose of the planes is to locate survivors, drop equipment to sustain them, and direct the boat to the scene. Ordinarily the boat is to pick up survivors, provide first aid, and deliver them ashore.

Offshore landings by rescue aircraft are not made when rescue can be accomplished by other means without jeopardizing the lives of the survivors. Occasionally rescue pilots, in their efforts to help fellow aviators, have landed unnecessarily, with disastrous results. However, there are unusual circumstances wherein the pilot of the rescue plane will determine that an open sea landing is necessary, as when a survivor is injured or suffering from exposure, when darkness is approaching, or when the nearest surface vessel is too far away. In such cases, the rescue pilot bases his decision on his knowledge of the situation, the capabilities of his aircraft, and the calculated risk to his own crew.

Rescue pilots are given broad discretion and are instructed that in cases where communications fail or emergency action is indicated, they are expected to act immediately on their own best judgment. In any case the final decision as to the feasibility of making an open sea landing can be made only by the rescue pilot.

Cycles of rescue operations.—A probable cycle of rescue operations will be as follows: A plane in trouble, or an accompanying plane, indicates potential or actual distress by radio and/or IFF signals (radio identification signal). Receiving stations then relay the information to the rescue operations center. The rescue operations center utilizes all available communications and direction finder facilities. It maintains plot of action, dispatches primary (and secondary when necessary) rescue craft, follows through all incoming and outgoing reports, monitors radio communications, when possible, arranges fighter support when required, keeps informed on weather, and designates "on scene" commander, who may be: senior officer present at scene, or commanding officer of the first air or surface craft to arrive on scene.

Rescue craft proceed, conduct search, and locate survivors. Survivors are then picked up, given medical attention, and landed ashore.

Aircraft distress procedure.—Rescue can be accomplished most expeditiously by the intelligent cooperation of personnel involved in a distress incident. It is important that the first step in effecting a rescue be taken by the pilot who experiences an emergency or who observes a distress incident.

The pilot in trouble must:

Immediately switch on his emergency IFF signal. (All aviation personnel must be familiar with this equipment in order to insure its positive use when needed and to prevent its misuse when not needed.)

Immediately transmit distress messages by radio to his own base if possible, or to any shore station, vessel or aircraft, giving identity and position. (An accurate position is important, but an approximate position reported promptly is preferable to delayed exact position.) Plain language should be used, if local regulations permit. Voice should be used in preference to CW (Code) whenever practicable.

Indicate that an emergency exists by any available visual means—flares, lights, hand signals, etc.

If time permits, transmit the following additional information: Altitude, course and speed. Nature of distress. Intentions (such as ditching, bailing out, etc.)

Rescue Operations Procedure.—The next step is taken by the base (or ship) which receives a message concerning distress. This base immediately should dispatch such assistance as may be available locally (if the distance is not too great) and notify rescue operations center. A form for such reports might be as follows:

1. Exact location: By a known geographic point or bearing and distance therefrom.
By latitude and longitude.
By the operating area grid position.
2. Time of crash.
3. Source of information.
Name of informant.
Address (or service and command).
Telephone number.
4. Type of plane and designating number.
5. All information known as to personnel.
Number involved.
Whether ditched or bailed out.
Whether known to be afloat, whether they are wearing life vests, whether in a life raft.
6. What search or rescue has been instigated locally.
By what agency.
What equipment available.

Obviously, all the above information is seldom available immediately but 1, 2 and 3 should in every case be included in the first report in order that intelligent action may be started. Additional information should be the subject of amplifying reports, as available.

Rescue operations center dispatches rescue aircraft and vessels as circumstances require, and delivers to them sufficient information to describe the situation and indicate the necessary action. Instructions to proceed, whether given directly or by radio, should inform rescue craft as to:

Type of aircraft and number of personnel.

Whether personnel ditched or parachuted, whether in sea with life vests or in life rafts.

Position (preferably in bearing and distance from land, or latitude and longitude).

Craft present at scene or proceeding.

Any other available basic information.

Subsequent information is reported to rescue craft by radio immediately upon receipt.

Rescue Plane Procedure.—When a search aircraft is dispatched on an emergency rescue

Figure 12-1.—Rescue operation by PBY.

mission, it immediately establishes communication with rescue operations center.

During the search all possible observation points for lookouts should be filled by aircrew members. The lookout or searcher who makes a sighting reports immediately to the pilot on the interphone, giving the relative bearing. The pilot immediately drops a float light or, if available, a radio marker buoy. Float lights can best be dropped when carried in flare chutes. The pilot should glance at his compass when he makes the drop so that he may combine plane heading and relative bearing to get the compass bearing of the survivor from the marker.

The pilot should not delay dropping the first marker until directly over the survivors, but should use the bearing and distance of the survivors from the marker for relocating them. Without this step—particularly if the survivors are in a heavy sea—the danger of losing them is very great.

When survivors are seen by pilot, he should:

1. Fly directly toward them, keeping them always in sight, and when passing over the survivors, he should drop a drift signal and dye sea marker directly alongside. Dye marker never should be dropped any great distance away from survivors, since it lasts a considerable time and may result in misleading other searching aircraft. Float lights are used whenever desired since they last only a few minutes and are recognized as having come from aircraft and not from survivors.

2. Switch on emergency IFF signal.

3. Report situation to controlling ship or station as soon as possible, and transmit homing signals for rescue craft. Under ordinary circumstances this report will include:

The position.

Number and condition of survivors.

State of sea.

Location of nearest surface vessel.

Plan of action.

4. Remain on scene until relieved, recalled, rescue is accomplished, or fuel is running low.

5. Facilitate rescue: To facilitate rescue, the rescue plane pilot may:

Drop flotation, sustenance and communication equipment, Life raft (multiple unit as-

sembly or airborne lifeboat if available), if survivors are without flotation aids. Ration kits and/or shipwreck kits, if it is apparent that rescue will be delayed.

Communication equipment and night marker signals, if near nightfall, or if forced to leave scene without being relieved.

6. Direct a rescue aircraft, boat, or other surface vessel to the scene.

7. Land and effect a rescue.

8. Request further assistance from rescue operations center. None of these actions precludes the use of any other.

There are several ways in which surface vessels can be led to the scene by a rescue aircraft:

1. The plane can drop float lights or fire pyrotechnics.

2. The plane can transmit homing signals for the ship.

3. The plane can zoom the survivor's position (preferably across the line of sight from the ship to the survivor.

4. The vessel can follow IFF signal and radar reflection.

5. If the vessel is not equipped with DF (direction finder), the homing procedure can be reversed: the plane can take a bearing on a signal from the vessel and give a course to be steered.

6. The plane itself can divert and convoy a vessel to the scene by the standard method provided that at least one aircraft is left with the survivor.

When leaving scene, for any reason, pilot must switch off the emergency IFF signal.

Unnecessary aircraft should leave the scene, as directed by the "on-scene commander." Casual aircraft should keep clear once survivors are located.

Rescue Boat Procedure.—The officer-in-charge of a rescue boat should consider his vessel as a component of the rescue team and be prepared to perform his mission as follows:

1. Proceed with all practicable speed to the distress scene.

2. Establish and maintain communication with rescue control and rescue aircraft.

3. Monitor proper frequencies on DF equipment for homing on orbiting aircraft, "Gibson Girl" or radio marker buoy signals.

Figure 12-2.—Rescue operations by AVR.

4. Conduct search operations in cooperation with rescue aircraft.

5. Locate and pick up survivors.

6. Render first aid to survivors as necessary.

7. Transfer seriously injured survivors from boat to plane and other surface vessel.

8. Buoy location of wreckage when practicable and when it does not interfere with assistance to survivors.

The plane or vessel effecting a rescue should report the following information to rescue operations center as promptly as possible:

1. Total number personnel rescued.

2. Total number personnel injured. (If seriously ill or injured give name, condition, treatment rendered and effect thereof.)

Figure 12-3.—Rescue craft, AVR and lighter-than-air craft.

3. Total number personnel dead or missing. (Give names if available.)

4. Destination to which proceeding and estimated time of arrival.

Rescue craft.—No airplane available today has been designed especially for rescue purposes, and no existing airplane possesses all the necessary requirements. However, several types of military aircraft are being used for rescue operations, and these are satisfactory if their limitations are borne in mind by operating personnel. Important characteristics in a rescue seaplane are:

1. Good visibility, for aerial search. Adequate communication and search equipment.

2. Suitable bomb bays and hatches for carrying and dropping equipment.

3. Rugged design, for rough water work.

4. Low wing loading and favorable power-weight ratio.

5. Good maneuvering and taxiing qualities on the water.

6. Suitable hatches and hoists for passing survivors.

7. Adequate facilities for berthing and treatment of survivors.

8. Moderate cruising speed.

9. Reasonably long range.

The *Catalina* airplane is common to all U. S. services in rescue operations. Where rough-water work is required, the seaplane type is preferable to the amphibian because of its lighter weight.

The *Mariner* has come into extensive use as a rescue aircraft.

The *Coronado* has been used for long-range search and for carrying rescue equipment.

Where operating conditions permit, rescue seaplanes can be stripped of all equipment not directly essential to rescue, to lighten the plane and thereby improve its possibilities in rough-water work. Removal of such items as heaters, oxygen equipment, torpedo racks, machine guns, self-sealing fuel tanks, etc., will reduce considerably the gross weight.

Rescue Landplanes.—Where water operation is not required, the landplane is of major value in air sea rescue as a search plane and carrier of droppable rescue equipment.

Land-based fighter planes have been used and carrier-based fighters are being used more and more extensively for rescue operations of limited range. Fighters are extremely valuable for getting to a survivor's position quickly and directing surface craft to the position. A group of such planes can sweep a large search area in minimum time.

Rescue boats.—Rescue Boats may be separated into four categories:

Self-sustaining offshore type.

Offshore, shore based type.

Inshore type.

Shallow-water type (swamp gliders, etc.).

Features of a rescue boat which must be considered in selecting a boat for use in a particular area are:

1. Maximum practicable delivery range under own power.
2. Lifts and weights involved in deck loading for delivery.
3. Fuel, oil and water capacities and rates of consumption.
4. Ease of maintenance.
5. Size of crews required.
6. Seaworthiness.
7. Communication equipment.
8. Casualty handling facilities.
9. Endurance range.
10. Speeds, maximum and cruising.

Lighter-than-air craft.—The lighter-than-air craft are used when available as rescue craft. The non-rigid airship has certain peculiar advantages including:

Ability to cover any area with a balance between area searched and thoroughness of search. In covering a well-defined area, an LTA (Lighter-than-air) can cruise slowly at low altitude and make use of its steady search platform and excellent visibility. It can hover in moderate winds, when it is desired to observe a particular position, or remain over a survivor. Ability to assist in coordinating rescue action on the scene. After a survivor has been located the LTA frequently can establish and maintain visual and verbal contact with him to determine his condition and situation.

Ability to drop or lower survival and rescue equipment with more accuracy than heavier-than-air craft (except helicopters). Ability to conduct night search at slow speed with the use of search lights. Ability to rescue survivors by means of lowering a harness similar to the chestpack parachute harness. (However, this maneuver is difficult even for experienced lighter-than-air pilots and requires a moderate wind.)

Helicopters.—The helicopter is in use in certain areas for limited operations. Difficulties experienced in present operational models are being overcome as rapidly as possible. Improved models are in design and at such time as they are placed in large scale production they will probably figure prominently in rescue operations.

SURVIVAL

Life raft drinking water.—Under conditions of minimum water loss, an individual consuming 75 to 125 grams a day of a food constituted of carbohydrate and up to 20 percent fat will not become severely dehydrated for at least 8 days if supplied with 500 cc. of water a day. Given the same amount of food, a water supply of 800 cc. a day will provide for water needs indefinitely under these conditions. In the presence of complete starvation, the water requirements are slightly augmented.

It seems likely that loss may be maintained at a minimum in all tropical ocean areas by observing the following procedures:

1. Preventing vomiting.
2. Minimizing evaporative water loss by:
   a. Refraining from unnecessary exertion.

b. Exposing the body, adequately protected against sunburn, to the breeze as much as possible.

c. Shading the body from the sun, without simultaneously cutting off the breeze.

d. Keeping the clothing wet with sea water in the daytime.

Procedures 2 b. through 2 d. should be discontinued when sensations of chilliness intervene, since cold and consequent shivering expedite exhaustion and cause water to be lost from the body unnecessarily.

There should be made available on life rafts, from all sources, a minimum of 500 to 800 cc. of water per man per day of the estimated maximum number of days before rescue. Rain catchment equipment should also be provided.

As regards the proper procedure for rationing water, uninjured survivors should drink no water the first day. Thereafter, if the supply is limited, water should be consumed at the rate of 500 cc. per man per day until the supply is exhausted. When finally no water remains, individuals can survive several additional days, providing that from the very start the survivors maintain unnecessary water loss from the body at a minimum by using the procedures recommended in an earlier paragraph.

Producing drinking water at sea.—Three particular methods of producing drinking water at sea have been developed. They are:

1. Removal of salts from sea water by addition of chemicals.
2. Distillation of fresh water from salt water by small fuel-burning stills.
3. Distillation of fresh water by "Solar Stills", using sun alone.

Chemical desalination is not based upon a new principle. Patents relating to this method were taken out as early as 15 years ago. The Navy desalination kit occupies the same space as one 12-ounce can of water, weights 2 pounds, and contains 6 briquets which will render 6 pints of water.

Fuel stills for distilling fresh water from sea water are not new in principle either, many of them have and are being used. But development of small portable stills designed for use in lifeboats and rafts is recent. The Navy obtained some 8 pounds safety stills for use in rafts on large patrol aircraft.

The solar still is the most recent of the three water producing methods. This still, which is standard equipment for single or multi-placed life rafts, can produce more than two pints of fresh water a day. Although the still needs direct sunlight to operate best, it will work to some extent if the overcast is not too heavy. It will not work at night or on very dark days. When the still is inflated it floats in the water alongside the raft. Sea water is poured through the funnel in the top of the still. The removal of salt from the water is accomplished by distillation. The sun's rays heat the sea water that drips on the black evaporator cloth stretched in the center of each still causing evaporation. Vapor condenses on the sides of the plastic cover in little beads which run down to the fresh water trap below the ballast tube. The salts do not evaporate, but remain in the black cloth. This salt is washed out through the drain in the bottom of each still. They are self cleaning and never require washing.

Life raft rations.—Because of limitations of space, no more than a fraction of the approximately 2,000 calories per day needed by a castaway can usually be provided in an emergency ration. A daily intake of 75 to 125 grams of a food constituted of carbohydrate and up to 20 percent fat effectively spares body water and tissue and hence should be included in raft kits. Up to 125 grams per day of such a ration is more than its weight in water.

On the basis of the information now available, and for several practical reasons, it would seem inadvisable to include more than 25 percent fat in a ration for use on lifeboats and rafts. Except as a matter of palatability, protein should not be contained in an emergency ration for these craft. Addition of protein in order to increase palatability is at the expense of the more physiologically economical carbohydrate. The concentration of any flavor should be minimal and a variety of flavors should be provided, if possible. The vitamins available in the rafts today merely stimulate the morale so far as castaways at sea are concerned.

The emergency ration now contained in Navy life rafts consists primarily of carbohydrates. They replaced the former emergency ration which consisted of chocolate, malted milk, and "pemmican". The new ration was designed to

Figure 12-4.—First evacuation flight by Navy.

be easily edible and physiologically compatible when the water supply is limited, to provide a variety of items, and to be compact and easily stowable in parachute back pack kits.

This emergency ration is packed in a 3 by 2 by 1 inch key opening tin container and contains the following items:

Number	*Item*
5	Sucrose-citric acid tablets.
10	Sucrose-lipid-citric acid tablets.
8	Sucrose-malted milk tablets.
2	Multivitamin tablets.
2	Sugar coated gum tablets.
1	Waterproof cellophane bag.
2	Clips for closing bag.

At present three of these cans are supplied per man in parachute seat type and multiplace rafts. A survivor consuming one half a can a day will derive about 190 calories daily.

AIR TRANSPORTATION OF PATIENTS

Not until after World War I was aerial transportation accepted as a method of transporting patients. The first known Navy transportation of a patient by air was at Key West in 1919 when one patient was transported in an H-1 boat. Prior to World War II patients were transported by air only on rare occasions. It was not until after the beginning of World War II that air evacuation became an organized program and this was the result of necessity and not of choice. An example of situations presenting such necessities was the air evacuation from Guadalcanal in 1942. These experiences in the movement of casualties with practically all degrees of wounds and illnesses proved that air evacuation was both safe and reliable.

In 1942, R4D planes were being used, aboard which approximately 12 to 16 patients were

Figure 12-5.—Evacuation from Okinawa.

transported. By 1945 the planes in use were R5D's which transported 30 to 34 patients. Then in 1947 the JRM (*Mars*) planes began transporting 100 patients (84 litter and 16 ambulatory) per trip between Honolulu and Alameda, California. Now, of course, we have planes which can transport much larger groups of patients.

Advantages of transportation of patients by air.—Transportation of patients by air has many advantages over surface transportation. Some of these are: (1) Greater morale building factor for men in combat to know that if they are injured or become ill that they will soon be moved by air out of combat area to rear area hospitals. (2) Conserves medical personnel and equipment in that movement by air is accomplished in a few hours, thus usually requiring only a flight nurse and flight corpsman. Slower means of transportation such as by ship requires much longer periods of time, necessitating the presence of doctors, additional nurses etc., and much more medical equipment. (3) Patients better tolerate short trips by air and so arrive in better physical and mental condition than they would if transported by slower means, such as by ship or train. (4) It is more economical to transport patients by air than by ship. Studies show that three R5D planes can move the same number of patients between two points that can be transported by a hospital ship. Three planes can operate much more economically than a hospital ship. (5) Some cases tolerate air travel whereas it is highly questionable whether they could tolerate a long sea voyage. Examples are cases of leukemia and metastatic carcinoma with marked anemia.

For humanitarian reasons the policy of the Navy in such cases is to return them to the Naval hospital nearest their home before they expire. This is accomplished by giving the patient several blood transfusions and then transporting him by air to the desired hospital. Such a procedure would be most difficult, if not impossible, by surface transportation in cases of long distances such as from China or the Phillipines to the United States. Numerous cases such as these have been successfully transported by air.

At the beginning of the program in 1942 medical personnel were not specially trained for air evacuation work but as the program progressed a special school was established to train flight nurses and flight corpsmen. This school gave them special training in the care of patients aboard aircraft.

Very soon after the beginning of the air evacuation program it was found that the patients could be better cared for if they were observed and studied in the hospitals by the flight medical teams before they were taken aboard for transportation. This procedure is referred to as "screening" the patient. In time it became the policy for each plane load of patients to be screened by the flight nurse and flight corpsmen who were to accompany them and also to be seen by the flight surgeon attached to the unit. The flight surgeon, after visiting the patients would advise any special care which was indicated for the patients on the flight.

Practically all types of cases have been successfully transported by air. A general rule to follow in determining whether or not a patient should be transported by air is to determine whether or not he will be adversely affected by altitude. The type patients generally not acceptable for air transportation are as follows:

1. Patients in such poor physical condition that the successful completion of their evacuation is doubtful, unless potential lifesaving measures are available at the destination hospital which are not available at the point of origin.
2. Patients with fatal prognosis in moribund or semi-moribund state.
3. Patients whose illnesses present a health menace. These cases include quarantinable diseases (small pox, typhus, plague, cholera, yellow fever, leprosy) and other contagious or communicable diseases where adequate caution to prevent spread is impracticable or not feasible.
4. Patients in shock.
5. Patients with coronary occlusion or angina pectoris, if an attack has occurred within thirty days.
6. Patients with severe anemia. Severe anemia is defined as corresponding to a red blood count of 2.5 million or less and/or a hemoglobin of 50% or less.

Figure 12-6.—One hundred patients transported on Mars.

During a hospital flight a complete record is kept of the patient. The flight nurse does this by use of a special form on which is recorded any changes in the patient's condition, medications given, etc. This record, with the patient's other records, accompany him to the hospital.

Experience has shown that mental patients tolerate air travel better than any other type of transportation. This is due to the fact that they can be sedated in the hospital and kept sedated during the flight. Sedation is not practical for other means of transportation because of the lengthy periods involved.

Cases of advanced pulmonary tuberculosis present a problem to air transportation in view of the fact that it is highly questionable how well they will tolerate altitudes at which flights are usually made. This problem has been solved by loading a plane with such cases and then making a special flight at low altitude. Such a procedure has been quite successful.

Other special type cases which have been successfully handled by air transportation are cases of poliomyelitis with respiratory paralysis which require a respirator. This is accomplished by use of a portable respirator which operates either directly from the ship's current of 24 volts or from a current of 110 volts. In case of emergency the respirator can be operated manually. These portable respirators are readily available upon request to the Military Air Transport Service.

The medical personnel in the air evacuation program greatly assist in the overseas trans-

portation of dependents because medical assistance is often necessary on such flights. This is due to the fact that there are often a number of pregnant women and small children aboard.

A Bureau of Medicine and Surgery Circular Letter (No. 47-143) describes the procedure for requesting transportation of patients, transportation requirements, instructions, etc.

AVIATION SAFETY

The interrelationship between human factors and the type of aircraft is especially pertinent in an analysis of accidents because neither the operating characteristics of the plane nor the performance of the pilot can be considered as completely separate variables. Only in isolated cases is it possible to apportion the causes of an accident to specific faults rather than to an accumulation of contributing factors. Many accidents that have been attributed to pilot error may have resulted from excessive demands on the air crews. While training and selection procedures may be improved, it is unlikely that human limitations in operating aircraft can be appreciably altered. The aeronautical engineer may, however, be able to simplify the duties of the pilot and thus reduce the likelihood of error.

Methods of Accident Analysis and Prevention.—There are three main classifications that might be conveniently used to describe the methods of accident analysis. The first includes *post accident* studies which attempt to allocate the blame for what happened and to suggest subsequent corrective measures. This method has been most widely used and lends itself readily to statistical treatment. The second is the study of *near accidents* and the third an *advance analysis* of all possible causes. The two latter methods place greater emphasis on preventive thinking and on the correction of faults as they are brought to light before an accident. They should be given primary consideration.

Post-accident analysis.—This method involves the tabulation of the various contributing factors believed to have caused an accident, although they rarely occur as single events. The tendency of certain basic causes of accidents to repeat themselves in a general way makes the tabulation of frequency distributions of some significance. Many breakdowns relating to causation have been proposed, but the following one is representative of the majority now in use and indicates briefly the usual distribution of responsibility:

1. *Human factors.*—By far the greater percentage of accidents is attributed to such human limitations as errors of judgment, inadequate training, poor technique, loss of emotional control, disobedience of orders, and exhibitionism. Some studies of accidents in air operation attributes 75 to 85 percent of the causes to human failure in one form or another. There are many shortcomings to this classification, not only because it presupposes a perfect pilot, but because there is a tendency to place the responsibility on errors of judgment when no other obvious cause is present. This category also includes errors made by the flight crew, maintenance personnel or supervisory personnel.

2. *Weather and meteorological factors.*—Poor visibility, extreme turbulence, icing, snow, hail, lightning, precipitation, static, and heavy rains are occasionally given as the direct cause of an accident. Some of these hazards may act in combination with poor weather-proofing of the windshield or ineffective deicing systems to increase the danger to a flight. Weather may occasionally be a factor in ground accidents; e.g., gale winds may upset an aircraft.

3. *Material failures.*—The most important cause of accidents in this classification is malfunctioning of the power plants, propellers, landing gear, or such accessories as hydraulic, electrical, and fuel systems. In addition, there may be structural failure of the airframe itself but this is rare unless the aircraft is placed under extreme stress.

4. *Poor flight characteristics.*—The aircraft may be well built structurally but have certain deficiencies in operation which involve both the performance of the plane and the ability of the pilot to compensate for them. It is well known that some models may have dangerous flight characteristics, such as the dropping of a wing on landing, excessive loss of altitude on turns, or inadequate warning of the onset of a stall.

5. *Airport and ground facilities.*—Many airports have inherent defects that may cause accidents. Runways may be inadequately lighted

or marked or too short for the type equipment being flown. Some airports even have embankments, levees, ditches, or other obstacles at the end of runways; e.g., they may be so laid out as to prevent a desirable field of view or to expose aircraft to perennial cross winds.

6. *Miscellaneous.*—This category includes the freakish types of accidents such as those caused by bird strikes or by temporary blinding with bright flashes of light from unexpected sources.

Considerable progress has also been made by the services in systematizing the study of accidents through standardization of accident-investigation procedures. A survey of the scene of the accident can be made and the relative positions of various parts of the wreckage studied. Very often the flight path of the airplane can be deducted by an examination of ground scars and of trees or brush broken by the propellers, landing gear, or wing tips. In this way the angle and attitude in which the plane struck the ground can be determined. For example, if the wreckage is confined to a small circular area, it may have dived directly into the ground. By similar projection analysis, it can sometimes be established whether the plane spun in, hit the ground in low level flight or was completely out of control while on instruments. There are many uncertainties and inadequacies in such methods, and great care must be exercised in attempting to reconstruct the sequence of events, particularly if there has been a fire and it is necessary to determine whether it started before or after the impact. Photographs, sketches, maps, and evidence from witnesses are often helpful for the permanent records and later study. Closer liaison between engineers and medical officers has contributed greatly to post-accident analysis, especially in correcting defects in the design of the seats, cockpits, and instrument panels. The nature of personnel injuries in relation to a study of the wreckage will often reveal whether the seats and safety harness were adequately stressed or whether protruding objects in the cockpit or on the instrument panel were contributing factors.

When a large number of accidents occur, as during the World War II, it is possible to put all available information on cards for use in automatic tabulating machines. Frequency distributions obtained by this procedure may be of significance in showing which variables have greater implications for safety. If a large number of crashes occur at night during approaches and landings, or because of failures in any one part of the plane, it may be possible to establish a single causative factor. Through such studies it has been possible to make notable progress in the safety program by changing the regulations to diminish the likelihood of the reoccurrence of any given type of accident. The fundamental weakness of this approach, however, lies in the possibility that the data may have been inadequately selected or improperly tabulated on the punch cards by someone who is not familiar with aircraft operation and that questionable inferences have been drawn from them. In many instances when there are no survivors and the plane is completely destroyed the accident must be reconstructed from circumstantial evidence alone, introducing additional sources of error.

Analysis of near accidents.—A study of near accidents is of more importance to the safety of operations than information about those that have already taken place because it is possible for the flight crews and engineers to suggest corrections in design or in operating procedure before a real mishap occurs. The greatest drawback in this method is the difficulty in enlisting the complete cooperation of the flight crews, for they might be reluctant to give evidence implying negligence on their part. When complete confidence is obtained between flight groups and management and when there is less readiness to assign an accident to human failure alone, this approach may be very productive of constructive criticism of both the operation and design of the aircraft and the performance of the air crews. Pilots have grounded themselves because of excessive fatigue, poor health or inadequate training on a particular type of aircraft; this cooperation was possible because complete confidence existed between the flight group, the operations officer, and the medical officer. Numerous illustrations can be given in which pilots have reported near accidents due to poor operating procedures, faulty design features in aircraft or defective airports. When corrective measures are not carried out, sooner

or later severe accidents occur. Near-accident analysis, however, places less emphasis on preventive measures than does the approach outlined below, which stresses advance analysis of all aircraft operations and aircraft design.

Advance analysis of accidents.—An effort should be made to prevent the occurrence of accidents by an advance analysis of possible contingencies that might arise while the plane is in flight. This method involves a study of (1) mistakes that the air crews may make and (2) every possible fault in the design of the aircraft itself. The point of view represented by the word *defect* or *fault* may be more fitting to use in this approach than accident. The implication is that it would be more fruitful to determine the predisposing factors leading up to a crash or near crash by studying the design and flight characteristics of the plane, as well as the limitations of the pilot and what may reasonably be expected of him. For example, it might be questioned whether the probable cause of an accident lies in the pilots failure to compensate for a plane's tendency to drop a wing in a turn or in a defect in the design of a plane. It would be appropriate to consider whether such a basic fault in flight characteristics could not have been corrected at some stage in the design and construction of the aircraft. If such a defect is present, it is only a question of time before some pilot "fails" and crashes the plane.

Accidents occurring in naval aircraft are reported and studied in accordance with *Aviation Circular Letter No. 97-48* through the use of a "Medical Officers Report of Aircraft Accident". These reports are now required on each accident resulting in injuries (treated or not), deaths, and all bailouts and ejections (including those resulting in no injuries). The flight surgeon or unit medical officer should submit this form direct to Chief of Naval Operations, Attention: Flight Safety, in accordance with instructions thereon. An example of the "Medical Officers Report of Aircraft Accident" is shown in Figure 12-7.

Protection of crews and passengers against high deceleration during impact.—When an aircraft strikes the ground at a sharp angle at high speed in crash landing, its structure collapses suddenly and the passengers are unlikely to survive. In extreme impacts there is a complete disintegration of plane and bodies. In many crashes, however, the angle and the force of impact are not extreme, and a substantial portion of the cockpit or cabin remains intact. This type of crash may be termed "marginal" and injury or fatality may not occur. In marginal crashes, injuries largely result because the occupants are thrown against those portions of the plane that remain intact.

The decelerations that the human body can tolerate vary greatly with the position of the body at the time of impact and with the duration and distribution of the impact force. A study that is directly applicable to the influence of the positioning of the body has been reported by Henchke. Human subjects assumed various positions on the platform of a large swing that could be stopped very suddenly. The maximum force in g which the human body can withstand in any given position was determined by the onset of headaches or other symptoms of cerebral concussion. The duration of the decelerative force for all positions was 0.01 sec. One position is of particular interest in aviation since it corresponds most closely to that of a person in a seated position and wearing a safety belt. The values of g were somewhat high since they probably referred to the decelerative forces on the swing rather than on the body and also because the duration was limited. It can be concluded from this study that safety belts, seats, and other items with which the subject is in contact at the time of impact should be stressed to withstand forces of at least 34g and preferably 40g to insure an adequate safety factor.

The importance of a proper distribution of pressure forces over the body during sudden impact has been demonstrated by DeHaven in a study of survival after falls from heights of 100 to 150 feet. He estimated that in some of the accidents that he has studied approximately 200g has been imposed on the body without serious results. This investigation was then extended in to the field of light aircraft accidents and an analysis has been made of the injuries incurred. The most important implications of these studies are that (1) the force of many accidents now fatal is well within physiological limits of survival, (2) needless

AVIATION CIRCULAR LETTERS

MEDICAL OFFICERS REPORT OF AIRCRAFT ACCIDENT
NAVAER-3960 (REV. 9-48) OP-REP-88-11

GENERAL INSTRUCTIONS

1. *This report shall be filed in the event of any and all aircraft accidents resulting in injuries to plane occupants, treated or not, regardless of extent or types, and ALL bailouts, injured or not.*
2. *Completion of the form shall be the responsibility of the flight surgeon serving as an ex officio member of the Aircraft Accident Board. He shall be assisted by the medical officer first reporting to the scene of the accident, or in the event no such officer reports to the scene, by the officer supervising treatment of the injured.*
3. *This form shall be prepared in duplicate, the copy being turned over to the Aircraft Accident Board and the original mailed direct to Chief of Naval Operations (FLIGHT SAFETY), Navy Department, Washington 25, D.C., within 96 hours following first examination of the injured. Where more than one aircraft is involved, separate forms must be completed for each craft wherein occupants were injured. (Additional copies may be prepared for use of squadron flight surgeons and other interested individuals.)*
4. *Include photographs illustrating impact(s), damage to cockpit, structures causing injury, etc.*
5. *Addenda are encouraged.*

PART I. ACCIDENT IDENTIFICATION

1. REPORT FROM *(Ship or station address)* | DATE

2. ACCIDENT OCCURRED *(Geographic location)* | TIME | DATE

3. PLANE COVERED BY THIS REPORT *(Bureau No.)* | *(Type)* | *(Unit assigned to)*

4. OTHER PLANE *(Bureau No.)* | *(Type)* | *(Unit assigned to)*

5. TYPE OF OPERATION

☐ LAND BASED OPERATIONS CONTINENTAL ☐ FOREIGN ☐ RESERVE PROGRAM ☐ TRAINING COMMAND (including refresher) ☐ CARRIER OPERATIONS

6. REPORT FILED BY *(Signature)* | *(Printed name)* | *(Rank)* | *(Date)*

PART II. INJURY CORRELATIONS

(ANSWER ALL of the following, even if opinion or estimate)

1. LIST PRECAUTIONS TAKEN IN ATTEMPT TO PREVENT, OR LESSEN DEGREE OF INJURIES. *(Outline briefly whether successful or not.)*

2. WHAT SAFETY DEVICES WERE UTILIZED? *(List failures to utilize, or failure of safety devices, and how these failures contributed to the injuries.)*

3. WHAT SPECIFIC PARTS OF THE AIRCRAFT CAUSED THE INJURY? LIST AND DESCRIBE. *(Entries of "no", "none", "sustained on impact", "undetermined", with no amplifying remarks and opinions will not be accepted.)*

BAIL OUT DATA

4. ☐ BAIL OUT ☐ ATTEMPTED BAIL OUT ☐ EJECTION SEAT USED ☐ SHOULD HAVE BAILED OUT BUT DIDN'T

5. REASON PILOT DIDN'T BAIL OUT

6. ALTITUDE OF PLANE AT TIME OF EXIT

7. ATTITUDE OF PLANE AT TIME OF EXIT *(if spin, type and direction)*

8. SPEED OF PLANE AT TIME OF EXIT KNOTS

9. APPROX. ALTITUDE, PILOT LEFT EJECTION SEAT FT.

10. APPROX. ALTITUDE, RIP CORD WAS PULLED FT.

11. APPROX. ALTITUDE, CHUTE OPENED FT.

12. WAS FREE FALL DELIBERATE? ☐ YES ☐ NO

13. WAS OXYGEN USED DURING DESCENT? IF SO WHAT TYPE EQUIPMENT?

14. METHOD OF EXIT *(except in ejection seat)* ☐ RIGHT ☐ LEFT

15. DID PILOT BAIL OUT TOO LOW FOR CHUTE TO OPEN? ☐ YES ☐ NO

16. LIST PERTINENT FACTS PERTAINING TO ITEM 2 ABOVE.

17. LIST CAUSE OF INJURY AS PERTAINING TO ITEM 3 ABOVE.

18. LIST ANY DIFFICULTIES EXPERIENCED AND/OR REMARKS ON ADDITIONAL SHEET.

19. SUBMIT PILOTS NARRATIVE OF ENTIRE EVENT ON ADDITIONAL SHEET.

PART III. PILOT DATA

1. HOW MANY PREVIOUS ACCIDENTS HAS PILOT BEEN INVOLVED IN, WHILE IN ACTUAL CONTROL OF AIRCRAFT?

2. ARE THERE ANY INDICATIONS THAT THE PILOT MAY HAVE BEEN SUFFERING FROM SOME PHYSIOLOGICAL ABNORMALITY, *(bends, auto-kinesis, blackout, etc.)* AT TIME OF ACCIDENT?

3. ARE THERE ANY INDICATIONS THAT THE PILOT MAY HAVE BEEN IN POOR PHYSICAL CONDITION *(illness, lack of sleep, recent over-indulgences, use of medicines, etc.)* AT TIME OF ACCIDENT?

4. ARE THERE ANY INDICATIONS OF UNUSUAL MENTAL CONDITIONS *(anxiety, poor adjustment, previous narrow escapes, etc.)* EXISTING PRIOR TO THIS FLIGHT? IF SO, OUTLINE BRIEFLY.

5. WAS THE SITUATION CONFRONTING THE PILOT AT TIME OF ACCIDENT IN ANY WAY UNIQUE *(unusually heavy traffic, distracting stimuli, recent narrow escape in similar circumstances, etc.)*? IF SO, OUTLINE BRIEFLY.

6. PILOT ERROR *(check applicable block)*

☐ JUDGEMENT
☐ TECHNIQUE
☐ VIOLATION

7. LIST SPECIFIC PILOT ERRORS *(DO NOT assign percentages)*

(OVER)

Figure 12-7.—Medical officer's report of aircraft accident.

AVIATION CIRCULAR LETTERS

PART IV. PERSONNEL INJURED (PLANE OCCUPANTS ONLY)

DIRECTIONS

1. *Under NAMES AND DESIGNATION NOs. OF INJURED PERSONNEL, list surname followed by initials. IN ALL INSTANCES, WHETHER INJURED OR UNINJURED, LIST PILOT IN NUMBER 1 POSITION.*
2. *At all other points on this form, each of the injured shall be designated merely by the number to the left of his name in the listing below.*
3. *Use additional sheets as necessary, filling separate form for each aircraft wherein occupants were injured.*
4. *Under RANK OR RATES, if Reserve, state Volunteer ("V"), Organized ("O"), Active Duty ("A"), or Active Duty Training Cruise Volunteer ("VT"), or Organized ("OT").*
5. *Under INJURY CLASS., use following key (N.A.C.A. standard with additions:)*
   Class "A" - Injuries resulting in death within 90 days.
   Class "B" - Serious injuries, including unconsciousness, fractures except simple of fingers and toes, lacerations involving muscles or causing severe hemorrhage, injury to internal organs, or any other injury which will probably incapacitate for 5 or more days.
   Class "C" - All minor injuries.
   Class "L" - Missing and presumed drowned.
   Class "M" - Missing.

NOTE: Later necessary changes from "B", to "A" in the ninety day period should be forwarded if known.

6. *Under DISPOSITION, use following key:*
   "D" Uninjured.
   "W" Treated and returned to duty without hospitalization.
   "X" Hospitalization.
   "Y" Autopsy performed.
   "Z" Remains to morgue without autopsy.

NAMES AND DESIGNATION NOs. OF INJURED PERSONNEL	SERVICE NUMBER	RANK OR RATE	DUTY ABOARD PLANE (OR ON GROUND)	AGE	POSITION OCCUPIED IN PLANE AT TIME OF ACCIDENT	INJURY CLASS.	DISPOSITION
1.			PILOT				
2.							
3.							
4.							
5.							

TOTAL NUMBER ADDITIONAL, UNINJURED OCCUPANTS

PART V. SUMMARIES OF INJURIES (PLANE OCCUPANTS ONLY)

DIRECTIONS

1. *Summarize all personnel injuries by placing designation numbers assigned in part IV in appropriate squares (e.g., if the pilot suffered severe shock, cerebral concussion and severe lacerations of head, a small figure "1" should be placed in all pertinent squares.)*
2. *If injuries are multiple extreme, list all major injuries.*
3. *Where injuries were fatal, indicate probable cause of death by placing an "X" after number in the pertinent square (e.g., if No. 2 were killed having suffered a cranial fracture and mild contusions of the trunk, an "X" should be placed after the "2" under CRANIAL FRACTURE.*
4. *Remarks and suggestions are encouraged.*

SHOCK		MILD	MODERATE	SEVEPE	
UNCONCIOUSNESS		SHORT DURATION—LITTLE SIGNIFICANCE		OTHER	
BURNS	DEGREE	1ST	2ND	3RD	CARBONIZATION ENTIRE BODY
	AREA	HEAD AND NECK	TRUNK	EXTREMITIES	
HEAD INJURIES		CEREBRAL CONCUSSION	MINOR FACIAL INJURIES	MAJOR FACIAL INJURIES	
		MINOR EYE INJURIES: ONE EYE		MAJOR EYE INJURIES	ONE EYE
		MINOR EYE INJURIES: BOTH EYES		MAJOR EYE INJURIES	BOTH EYES

FRACTURES

TYPE / BONES	SKULL		VERTEBRAE					RIBS	PELVIS	U. ARM		L. ARM		HAND		U. LEG		L. LEG		FOOT	
	CRANIAL	FACIAL	CERV.	THOR.	LUM.	SAC.	COC.			LFT.	RT.	LFT.	RT.	LFT.	RT.	LFT.	RT.	LFT.	RT.	LFT.	RT.
SIMPLE																					
COMPOUND																					
OTHER																					

AREA OF INVOLVEMENT	LACERATIONS			CONTUSIONS			ABRASIONS		
	MILD	MODERATE	SEVERE	MILD	MODERATE	SEVERE	MILD	MODERATE	SEVERE
HEAD AND NECK									
TRUNK									
EXTREMITIES									

AMPUTATIONS

TYPE	ARM		FOREARM		HAND		FINGERS		LEG		LOW. LEG		FOOT		TOES		HEAD
	LFT.	RT.	LFT.	RT.	LFT.	RT.	ONE	MORE	LFT.	RT.	LFT.	RT.	LFT.	RT.	ONE	MORE	
TRAUMATIC																	
SURGICAL																	X X X X X

INTERNAL INJURIES (SUMMARIZE IF AUTOPSY WAS PERFORMED)

REMARKS

NAVAER-3390 A TOTAL OF ____ ADDITIONAL SHEETS RELATING TO THIS ACCIDENT ARE ATTACHED OP-REP-55-11

Figure 12-8.—Medical officer's report of aircraft accident.

injuries—both serious and fatal—are caused by the placement and design of certain objects and structures.

Investigations of internal injuries in personnel who have been subjected to large forces for short duration in military-aircraft accidents have been made by Haas. Although he placed emphasis on the extent and nature of these injuries, he concluded that the prevention of injuries can best be achieved by determining which parts of the aircraft are responsible for contact injuries, to what extent structural collapse is involved, and how adequate the provisions for emergency exits were.

In many crash landings the airplane is not stopped immediately on impact but often skids along the ground before coming to rest. When the angle of impact is large and the ground soft, penetration of the airplane into the ground for a measurable distance tends to absorb the shock. Even when the surface is more solid, the motion is checked less abruptly because of the telescoping of the aircraft structure. Thus, even under extreme conditions, the collapse of the fuselage in the proper direction can go far to reduce the decelerative forces on the passengers and the crew. The aeronautical engineer can contribute to survival in marginal accidents by a design in which the crew or the passengers are in a fairly rigid inner structure surrounded by supporting members which, as they are crushed, will reduce the force on the cockpit or cabin itself.

Studies of accidents have shown that seats of light construction often increase the severity of the injury either by collapsing under downward pressure or by tearing loose when the horizontal deceleration is great. In a number of cases where belt fastenings have held under the impact, the seats have been torn loose and thrown forward with disastrous results to the occupants.

The importance of a proper distribution of forces between the body and the supporting structure has been brought out in reports of survival in aircraft accidents. Standard ditching procedures in the services recommend (1) a seated position facing the tail of the plane with the knees drawn up and with the head and back braced against a solid structure, or (2) a prone position on the floor with the head to the rear, knees slightly bent, and feet firmly braced against a solid structure. The passenger who is riding in a seat facing backwards to the forward movement of the plane stands a better chance of escaping injury because the impact forces are more widely distributed over the body. If local injury to the neck is to be prevented, the head must be supported by a headrest or the back of the seat. There are various obstacles to be overcome in achieving backward seating in air transports; the operators hesitate to include such an arrangement in their specifications for fear of popular disapproval. Some designs, however, have provided seats facing alternately backward and forward. The use of tricycle landing gear has eliminated the passenger's tendency to slide off the seat—which is one of the main objections to backward seating—by maintaining the fuselage in a horizontal position when the airplane is on the ground. Some of the usual objections to riding backward on a railway coach or bus are not present in flight because of the absence of a sense of motion and of reference objects in the immediate field of view which create disturbing reactions chiefly of a visual nature. In so far as these psychological responses of the passenger during flight are concerned, there is nothing to prevent reversing the conventional direction of seating.

Oxygen installations.—The wide experience with nonpressurized planes at relatively high altitudes obtained by the military services during the World War II has afforded many graphic instances of fatalities and near fatalities that have occurred either because of faults in the system or because of inadequate indoctrination and operating procedures. Oxygen want would not present a major problem on pressurized planes, however, unless there were a failure in the supercharging system or the cabin structure.

Advance analysis of faults in airport design.—Another aspect of aviation deserving attention is the extent to which the design of airports may be a factor contributing to accidents. In so far as accidents are concerned, some of the more important considerations for airports are as follows: (1) the length of the runways should be adequate (a) to handle the most advanced type of equipment with wide margins

of safety and (b) to permit the aircraft to roll safely to a stop in the event of engine failure at the point where its wheels lose contact with the ground during take-off. (2) The runways must be able to withstand the impact and frequent use of large aircraft. (3) Because of the increasing wing span, it is important that the width of the runway permit considerable leeway for maneuvering or yawing in the event of the loss of an engine to avoid striking other aircraft or obstacles or going off the runway onto a soft shoulder. (4) Attention should be given for surface drainage in the tropics and snow removal in the temperate and northern regions. (5) The location should be selected with regard to the presence of obstacles such as hills, embankments, trees, radio towers and tall chimneys that cannot be easily removed. (6) A careful study should be made of the prevailing winds in relation to the direction and layout of the runways. (7) The design and layout of the lighting facilities should be studied in relation to their effect on the pilots as well as their value for ground personnel.

Advance analysis of personnel failures.—After each transport accident an attempt is always made to allocate the causes or place the responsibility on some definite factor such as the pilots, other personnel, the aircraft, the ground and navigational facilities, or the regulations governing the operations. Each of the interests represented naturally tries to establish its lack of responsibility for the crash. In a number of cases those responsible for the performance of the equipment tend to place the blame on personnel failure, while the air crews often feel that too much has been expected of them or the operating conditions were unfavorable. The reconstruction of what happened during the crash by a post-accident analysis is subject to many errors and is often complicated by the efforts of these various groups to protect their special interests. In general, both the pilot and the airplane, and often others, are involved in each crash and no one can be completely relieved of some responsibility. If the aim is to prevent accidents, it would appear to be more reasonable to raise the question as to what can be done to improve the equipment in relation to procedures involving the human element.

The majority of accidents in the past have been attributed to human error of two general types. The first, which is rarely encountered in air operations, includes those resulting from recklessness or gross negligence on the part of the air crew. It is assumed that this type will be eliminated either by more careful selection or by better training and improvement in morale. The more important group comprises those resulting from errors of judgment or of technique; it is this type with which we are concerned here. Where judgment or technique is concerned, sooner or later a particular pilot encounters a set of circumstances with which he is unable to cope, and under tension of the setting he becomes involved in an accident. Even the most highly skilled personnel may be presented with a problem so difficult that the chance of error becomes very great. For this reason it is felt that planes should be designed for the average pilot rather than for the most capable pilot, providing wide margins of safety for each contingency that might arise.

The location and inadvertent use of controls.—The importance of separating certain essential switches or controls and of having guards prevent their being manipulated inadvertently or prematurely has been demonstrated repeatedly in operating experience with both civilian and military aircraft. Frequent confusion has occurred between landing gear controls and tail-wheel locks or flaps when constructed similarly and located adjacent to each other.

Confusion in reading or in setting instrument dials.—It is well recognized that a pilot usually has little difficulty in reading each instrument when time is not a vital factor. In most critical situations, however, the indications from many instruments must be comprehended quickly and more or less simultaneously. If an error is made under such circumstances the question may be raised as to whether the design or the pilot was at fault. Thus the instrument panel should be so arranged as to prevent the possibility of confusing one instrument with another.

Illusions from identification lights, instruments, and controls.—The role of illusions, especially those of spatial orientation, is thoroughly recognized and stressed in pilot-training

programs. This source of error, however, is not always appreciated in the design of the instruments and the exterior lighting of aircraft. For example, accidents may arise from misinterpretation of identification lights on other aircraft because of the *autokinetic* illusion. This visual illusion may be described as the tendency of a single fixed point of light to seem to move in a random fashion when looked at steadily against a dark background. If a subject is asked to localize such a source of light he will usually state that he cannot do so with certainty because the light appears to move about. This apparent shifting of a light that is actually fixed is known in psychological terminology as "autokinetic movement". In laboratory experiments it is not uncommon for a mild hypnotic state to be induced while steadily observing a small light. In fact, this principle has long been used in psychological medicine as an aid in inducing hypnosis.

The existence of illusory phenomena problems was recognized in aviation after several accidents due to these causes. Pilots have become involved in difficulties not only while observing another plane in flight, but also in identifying lights, markings, and fixed structures such as bridges and smokestacks. Since 1941, corrective measures in the form of double tailed lights blinking alternately have been required by the CAB as a result of an accident. The regulations now provide for a light at each wingtip and at the top and the bottom of the fuselage, approximately in line with the forward position lights. In addition there must be two alternately flashing lights (one red, one white) some distance apart on the tail of the plane. This complex light pattern tends to destroy the autokinetic illusion and enable the pilot to identify with less confusion another aircraft in flight at night. The military services became more interested in the problem during the World War II after several accidents occured, especially during formation flying night.

Studies both in the laboratory and during formation flights at night, as reported by Graybiel and Clark, have shown that the conditions favorable to this illusion are (1) a nearly dark environment, (2) a small single stimulus of low intensity, (3) steady fixation, and (4) fatigue, either general or ocular. It is easy to imagine how such a set of circumstances in aviation may place the pilot in jeopardy. The pilot should rely on the instruments if there is any doubt or conflict between his perceptions and the instrument readings.

Problems involved in instrument vs. contact flying.—It is a well known fact that a high accident rate occurs during the changeover from contact to instrument flying. In recent years, serious accidents have occured, particularly in approaches and landings at night or under adverse weather conditions. Emphasis is placed on the problems confronted by the pilot in (1) making the transition from one to the other in landing and takeoff and (2) choosing between contact and instrument flying under adverse operating conditions. The pilot naturally feels more secure when he is able to see outside the plane, even though his view may be quite inadequate. For this reason pilots often choose to go on contact when a more proper procedure would be to use instruments.

The importance of night vision in air operations.—It is extremely difficult to prove that any specific accident or near accident occurred solely because of the absence of good night vision on the part of the pilot. It is relatively easy, however, to select a number of accidents in which the probable lack of night vision under condition of low illumination at the time of the accident is a common factor. The most frequently encountered situations in which difficulty from this source may be expected are as follows: (1) on night takeoffs from well illuminated runways, a critical time occurs when the end of the runway is reached and the pilot goes off contact onto instruments. At that time the airman may suddenly be in complete darkness, he is usually at very low altitude, and any other aircraft or obstructions in the vicinity create real collision hazards. (2) Landings at the end of long flights may involve a certain amount of risk because the visual efficiency of pilots is at low ebb. Simple fatigue may have been accentuated by anoxia or carbon monoxide during flight, or the decrease in light sensitivity due to anoxia may have been intensified by low blood sugar resulting from prolonged fasting. (3) The need for good outside

Figure 12-9.—How the gyro-horizon appears to the pilot.

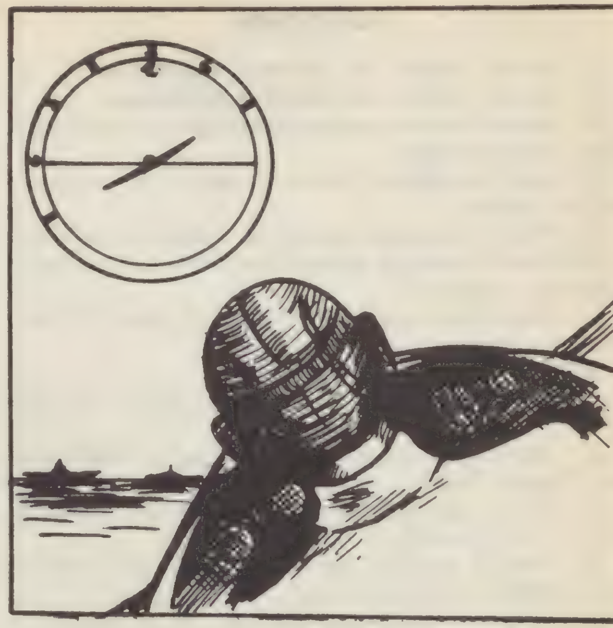


Figure 12-10.—How the pilot must interpret his gyro-horizon.

visual aids is particularly important at twilight or night levels of illumination. Poorly lighted airports present obvious dangers during landing and takeoff procedures, but even during cruise it may be necessary for the pilot to look outside the plane to observe other aircraft or meteorological conditions such as clouds and storms which can be by-passed, terrain and mountains if the plane is blown off its course, or important landmarks, groundmarks, ships at sea, and other piloting and navigating aids. (4) On large aircraft the lighting of the control cabin is not usually designated for maintaining the dark adaptation; if the pilot in the course of his duties leaves the cockpit to visit one of the other stations he may destroy his ability to see under low illumination. Such a loss of night vision would seriously handicap him in returning to the controls should an emergency occur. Occasionally there is no provision for light traps to keep the bright lights in the control cabin from influencing the pilots in the cockpit.

Disorientation caused by misinterpretation of the gyro-horizon.—Any circumstance which decreases a pilot's ability to localize his position or attitude in space can be considered a cause of disorientation. Misinterpretation of the gyro-horizon, which occasionally occurs, causes disorientation and crashes.

It takes several hours to teach a pilot to interpret the gyro-horizon. When he uses the instrument for the first time, the horizon indicator appears to move as he banks his plane, while the little plane on the instrument appears level, since its wings always maintain the same relative position to him — at right angles to his longitudinal axis. (See figure 9.) He must be taught that the horizon indicator remains in a fixed position with respects to the actual horizon while the little plane on the instrument and the plane he is flying revolve around it, as shown in figure 10.

Occasionally a pilot who has stared intently at the instrument panel during an instrument flight becomes the victim of a reversal of perception. He perceives the horizon bar tilting rather than himself tilting with respect to the horizon. When he is making a turn to the left, he sees the horizon bar tipped to the right as shown in figure 9 and endeavors to level with respect to himself by lowering his left wing. If his angle of bank to the left then becomes steeper, and his nose drops, a graveyard spiral may result. The chances of this mistaken perception occurring are increased if he has been under a strain for a long time and fatigued.

QUESTIONS

1. Briefly outline the general organization of an ideal air sea rescue operational organization.
2. Briefly describe the important characteristics of a good rescue seaplane.
3. List the different types of rescue craft used in air sea rescue.
4. What procedures should be instituted in order to keep water loss at a minimum in tropical ocean areas while on a liferaft?
5. Name three methods of producing drinking water from sea water.
6. Briefly describe a "Solar Still".
7. Briefly describe the emergency ration now used in Navy liferafts.
8. What is the reason for "screening" patients prior to a hospital flight?
9. What type patients are generally not adaptable for air transportation?
10. Briefly describe the different methods of accident analysis and prevention.
11. When is the Naval Medical Officer Report of Aircraft Accident submitted?
12. Briefly discuss illusions from identification lights.
13. Briefly discuss the importance of night vision in air operations.
14. Briefly discuss disorientation caused by misinterpretation of the gyro-horizon.

BIBLIOGRAPHY

1. Head, Air Sea Rescue Agency, *The Air Sea Rescue Manual*, 20 June 1945.
2. Bureau of Naval Personnel, *Handbook of Survival in the Water*, NavPers 16046, 1947.
3. *BuMed News Letter*, "Aviation Supplement," Vol. 5, No. 1, 6 July 1945.
4. McFarland, Ross A. Ph.D., *Human Factors in Air Transport Design*, 1946.
5. Air-Sea Rescue Agency, *Air Sea Rescue Bulletin*, July 1944.
6. Air-Sea Rescue Agency, *Air Sea Rescue Bulletin*, Oct. 1944.
7. Air-Sea Rescue Agency, *Air Sea Rescue Bulletin*, Dec. 1944.